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Construction Engineering Research Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Missiles at the Cape: Missile Systems on Display at the Air Force Space and Missile Museum, Cape Canaveral Air Force Station, Florida

Roy McCullough

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Foreword

This study was conducted for Patrick Air Force Base. Florida, under MIPR No. N12FY00000149, “Documentation of Rocket and Missile Static Displays, Launch Complex 26, Cape Canaveral Air Force Station, Florida. The technical monitor was Mr. Mike Camardese, Cultural and Natural Resources Program Manager, 45 CES/CEVC.

The work was performed by the Land and Heritage Conservation Branch (CN-C) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Julie Webster. Part of this work was done by Roy McCullough, McCullough Historical Research, 309 North Busey Avenue #2, Urbana, IL 61801 under DACA42-00-P-0322. Dr. Lucy A. Whalley is Chief, CEERD-CN-C, and Dr. John T. Bandy is Chief, CEERD-CN. The associated Technical Director was Dr. William D. Severinghaus, CEERD-CV-T. The Acting Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL John Morris III, EN, and the Director of ERDC is Dr. James R. Houston.

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1 Introduction

Background

Cape Canaveral Air Station (CCAS), FL has played a tremendous role in the American space program that began largely as a result of the Cold War. America's official entry into space occurred on January 31, 1958 with the launch of the Explorer I satellite. The American civilian and military space programs each trace their beginnings to this launch. Although officially conducted as a scientific exercise as part of the nation's participation in the International Geophysical Year, the Explorer launch, conducted by an Army team, had tremendous military implications as well. The U.S. military soon began developing, testing, and deploying several types of satellites including surveillance, reconnaissance, and communication satellites that would prove invaluable to this nation's political leaders and military planners during the Cold War and beyond. At the same time, the launching of scientific and application satellites began greatly expanding our knowledge of the universe and revolutionizing the way in which we live in our world. Although the creation of the National Aeronautics and Space Administration (NASA) in October 1958 officially separated the nation's civilian science and application satellite programs from the military programs, both programs continued to directly benefit from the accomplishments of the other.

In 1980, Congress enacted PL 96-344 that directed the Secretary of the Interior to conduct inventories evaluating historic properties associated with the early space program. By 1990, Congress enacted PL 101-511 emphasizing the heritage of the Cold War. This law requires the United States Air Force to "inventory, protect, and conserve the physical and literary properties and relics of the Department of Defense, in the United States and overseas, connected with the origins and development of the Cold War." In addition to PL 96-344 and PL 101-511, all federal agencies must comply with the National Historic Preservation Act of 1966 (NHPA), as amended. Section 106 of the NHPA requires federal agencies to identify and evaluate properties under their jurisdiction that are potentially eligible for the National Register of Historic Places (NRHP) prior to proceeding with any undertaking that may effect those properties.

In 1993, CCAS's Launch Complex 26, a dual pad complex, was determined eligible for listing on the National Register of Historic Places under NRHP Criterion

A (association with "events that have made a significant contribution to the broad patterns of our history"). Launch Complex 26 is also used for Cape Canaveral's Space Museum and is the home of approximately 50 military rockets and missiles on static display.

Objective

The objective of the research is threefold. First, it will provide expertise in the inventory, evaluation, and recordation of rockets and missiles on static display at Launch Complex 26 and will enable CCAS to successfully comply with federal preservation legislation. Second, this research will provide valuable information towards understanding CCAS's role during the United State's civilian and military satellite space programs and will help CCAS comply with federal preservation legislation. Third, this documentation will supplement on-going research to determine the significance of the military's technical and scientific rocket and missile program.

Approach

Task 1: Conduct intensive on-site and archival research of the rocket and missile static displays on Launch Complex 26. The research will include literature searches, oral histories, data collection for facilities documentation, black and white 35mm photography, and acquisition of rocket and missile specifications.

Task 2: Based on the data gathered during task 1, prepare and complete a document on the approximately 50 rocket and missile static displays. The document will include: history of the military space program; history on each missile system represented by the rocket and missile static displays; black and white historic photographs; black and white current condition photographs.

Mode of Technology Transfer

The completed documentation will be provided to Patrick Air Force Base.

This report will be made accessible through the World Wide Web (WWW) at URL:

http://www.cecer.army.mil

Missiles at the Cape

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Missile Systems on Display at the Air Force Space and Missile Museum, Cape Canaveral Air Force Station, Florida

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Section I

Historical Background

1. INTRODUCTION

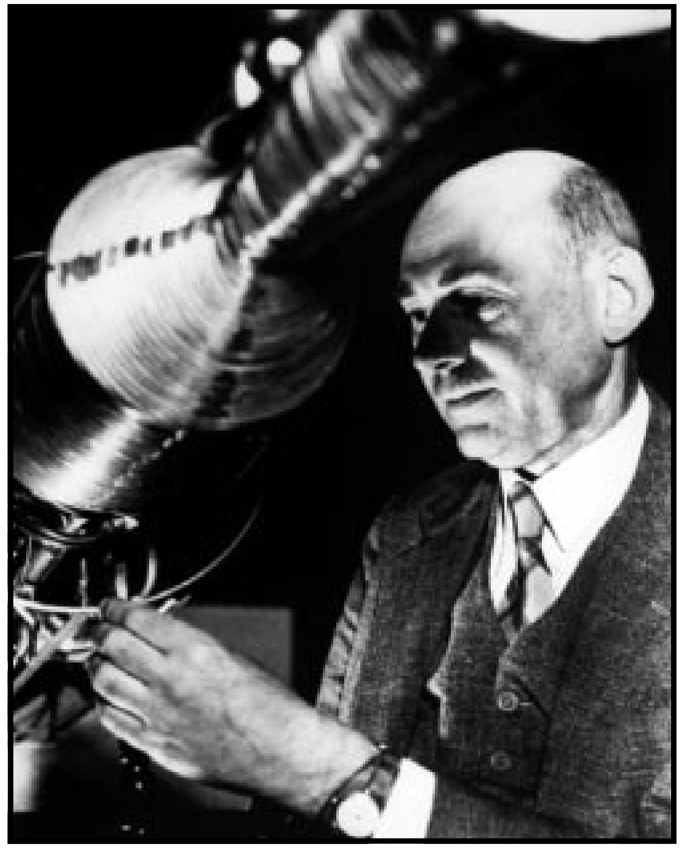
Cape Canaveral Air Force Station (CCAFS) has played a pivotal role in the research, development and testing of the majority of the United States' missile and space programs. The Air Force Space and Missile Museum at CCAFS has assembled an impressive array of rockets, missiles and other associated hardware that highlights this role and that conveys a sense of the evolution of rocketry and the rapid advances in missile technology. All branches of the service are represented by these displays. One finds missiles developed by the US Army and intended for tactical use on the battlefield, such as the Lacrosse and the Honest John, resting side by side with US Air Force intercontinental ballistic missiles (ICBMs), such as the Atlas E and the Titan I. One sees tall, slender sounding rockets such as the Aerobee-Hi next to compact decoy missiles intended to aid Strategic Air Command (SAC) bombers in the penetration of enemy air space. The US Navy's submarine-launched Polaris A-1 shares the field with the US Army's famous Redstone. One finds first-generation cruise missiles, such as the Matador and the Snark, side-by-side with the Minuteman, one of the most modern examples of missile technology. One finds powerful exemplars of nuclear military might sharing the field with rocket boosters that allowed humans to undertake an incredible journey to the stars. Taken together, the displays at the Air Force Space Museum at Cape Canaveral Air Force Station tell an impressive story about the United States' first efforts in the field of rocketry and subsequent stunning advances in missile technology. This report is intended to provide a brief background for each of the missile systems on display in the Air Force Space Museum's 'Rocket Garden.'

2. HISTORICAL BACKGROUND

The United States' first efforts in rocketry date back to the 1920s and 1930s and revolved around the work of Robert H. Goddard. Goddard conducted experiments with rockets in the 1920s and 1930s, carrying out the first recorded launching of a liquid-propelled rocket in 1926. Some of Goddard's more impressive achievements include: adapting the gyroscope to guide rockets, installing movable deflector vanes in a rocket exhaust nozzle scope to guide rockets, patenting a design for a multistage rocket, developing fuel pumps for liquid fuel motors, experimenting with self-cooling and variable thrust motors, and developing automatic parachute deployment for recovering instrumented rockets.

Around the time Goddard was conducting his experiments, the Germans were also engaging in rocket research. In 1937 and 1938, they established huge research and test facilities at Peenemünde on the Baltic Sea where they developed the V-1 "buzz bomb" and the more advanced V-2 ballistic rocket. Although the US military experimented with some crudely developed guided missiles during World War II, there was not much interest in rocketry among United States military leaders until the Germans began firing their V-1 and V-2 rockets at Allied cities in the summer of 1944. Allied anti-aircraft batteries quickly learned to shoot down the slow-flying V-1. There was no defense, however, against the 3,500 mile-per-hour V-2. The German V weapons made it clear that missiles would revolutionize the future of warfare. Recognizing this, the different branches of the US armed services scrambled to create their own missile programs, each hoping to gain future operational and deployment responsibility.

Immediately after World War II, the Army brought several hundred German engineers and scientists, including Dr. Wernher von Braun, to the United States during "Operation Paperclip." The Army organized a team of these scientists at Fort Bliss, Texas to conduct studies concerning the development of long-range surface-to-surface guided missiles. In an effort to refine the German V-2, these scientists began helping the Army test launch captured V-2 rockets at White Sands Proving Ground, New Mexico, in May 1946. In 1950, the Army moved the team to the Redstone Arsenal in Huntsville, Alabama, where they began to develop the Redstone missile.


Robert H. Goddard (NASA)

The Navy and Air Force also began their own missile programs in the 1940s. For a brief time, however, it appeared that a single national guided missile program might be established to eliminate duplication of effort among the services. The Army and Navy both favored such a development. But the Air Force (at that time still known as the Army Air Force or AAF) strongly opposed such a plan. AAF officials feared that a single program would jeopardize their chance of gaining sole responsibility for development and deployment of long range guided missiles. Consequently, fierce inter-service rivalries developed as each service sought to define its role and mission in the development and control of guided missiles.

In 1949, Secretary of Defense Louis A. Johnson initiated a review of the nation's missile programs in an attempt to clarify the roles of each service branch and to reduce the waste resulting from the duplication of effort. The Air Force emerged from this review with "formal and exclusive" responsibility for developing long range strategic missiles and short-range tactical missiles. Even after the review, however, both the Army and Navy continued to conduct missile "studies" that eventually progressed to the development stage.

In addition to this inter-service bickering, a more practical obstacle to long-range missile development in the United States was the lack of a range large enough to test the new long-range missiles. The nation's largest missile range in 1946, the White Sands Proving Ground, was only 150 miles long. For the United States to develop long-range missiles, a new missile proving ground would have to be established. In October of 1946, the Joint Research and Development Board of the War Department (later the Department of Defense) created the Committee on Long Range Proving Grounds. The War Department charged the committee with the task of selecting a site that would be suitable for a long range proving ground.

2.1 The Selection of Cape Canaveral as a Proving Ground for Long-Range Missiles

The committee considered sites in California, Georgia, Texas, and Florida. The committee's first choice was the El Centro Marine Corps base in the Gulf of California area. The United States government immediately initiated negotiations with the Mexican government to secure sovereignty rights for tracking stations. These negotiations failed and the committee then recommended the Cape Canaveral area in Florida. Cape Canaveral had several factors working in its favor, not the least of which was an over-water range that would allow long-range missile flights over an area relatively free from major shipping lanes and inhabited land masses. In addition, the numerous islands extending out into the Atlantic Ocean offered suitable locations for permanent stations to track missile flights and record performance information. The relative isolation of the Cape area was ideal for safety and security reasons and the weather conditions of the area would allow for year-round operation. Furthermore, the Banana River Naval Air Station, located only about twenty miles from the Cape, would make an ideal support base. Aside from these advantages, locating the missile proving ground at Cape Canaveral also had economic advantages. The US government already owned portions of the Cape and the undeveloped land on the Cape was considerably less expensive than land at other locations.

The Department of Defense accepted the committee's recommendations and officially chose the Cape Canaveral area as the site for the envisioned missile test center. In May of 1949, President Truman signed Public Law 60 authorizing the establishment of the joint long range proving ground to be used by the Army, Navy and Air Force for the development and testing of missiles and other weapons. The Department of Defense assigned responsibility for developing the range to the newly created Department of the Air Force. Brigadier General William L. Richardson was named to direct the project. During the next few years, the US government acquired land in the Cape area and began negotiations with the British government to acquire islands in the Bahamas and West Indies for use as tracking sites. The negotiations concluded with the signing of the Bahamas Agreement in July of 1950, permitting construction of downrange stations on such islands as Grand Bahama, Grand Turk, Antigua and Ascension. Future downrange stations were added as far away as Pretoria in South Africa.

On 10 June 1949, the Banana River Naval Air Station was reactivated and an advance headquarters was set up there on 1 October 1949. Brigadier General Richardson assumed command the following April. The name of the Banana River Naval Air Station was changed in August of 1950 to Patrick Air Force Base in honor of Major General Mason M. Patrick, the Army Air Corps' first Chief. During that same year, construction began on the first missile launching pad (Pad 3) and the first support facilities at Cape Canaveral. In June, the installation at Cape Canaveral was officially declared operational and became Operating Sub-Division #1 or Station 1 of the Joint Long Range Proving Ground.

Over the years the installation at the Cape has undergone numerous name changes. Initially known as the Joint Long Range Proving Ground, the range became known as the Long Range Proving Ground in 1950. By 1952, it was known unofficially as the Florida Missile Test Range and on 1 May 1958, it was officially designated the Atlantic Missile Range. The name was changed once again in May of 1964 to the Air Force Eastern Test Range (AFETR). The latest redesignation occurred in the fall of 1990 when the range became simply the Eastern Range. Operating Station 1 or Sub-Division #1 was commonly known as Cape Canaveral from 1950 to 1963. In 1951, the area was known as Cape Canaveral Auxiliary Air Force Base and, in 1955, as the Cape Canaveral Missile Test Annex. In November 1963 the Cape area was officially named Cape Kennedy in honor of President Kennedy, but early in 1974 the name was changed back to Cape Canaveral. In April 1994, the name was changed yet again to Cape Canaveral Air Force Station.

2.2 Land Acquisition in the Cape Area

The US government contracted with Sverdup and Parcel to conduct a land survey of the Cape Canaveral area in January of 1948. The government began acquiring land on the Cape in 1950. Of the original 12,000 acres acquired, 2,328 acres were purchased by the end of 1950. The US government acquired the south half of the launching area as a result of condemnation petitions from April to June of 1950 and acquired the north half of the launching area in June of 1950. In 1951, the value of government-acquired land and facilities at the Cape totaled about $7,500,000. In 1956 and 1957, the government acquired an additional 682 acres in the south Cape area and from 1956 to 1959, 1,924 acres were acquired in the north Cape area. The total acreage at the Cape by 1959 was approximately 14,600 acres. Later acquisitions brought the total up to 15,804 acres.

2.3 Early Construction at Cape Canaveral

Extensive construction was necessary to prepare Cape Canaveral for its role as a missile research and development test center. The first facilities built at Cape Canaveral were technologically primitive by today's standards. Many of the early structural designs became obsolete as missile technology advanced. Although facilities within launch complexes were often adapted and reused for other functions, launch complexes designed for one type of missile or missile series were rarely used for subsequent missile programs. Complexes that were useful for one missile or missile series were not configured to handle the later, often larger and more sophisticated missiles. It was generally more cost effective to build a new launch complex than to adapt an existing launch complex. Some obsolete complexes were salvaged for reusable metal, sold to scrap metal dealers, demolished, or in a few cases refurbished for other programs.

The Department of Defense designated the Corps of Engineers as the prime construction agency at Cape Canaveral and nearby Patrick Air Force Base. The Jacksonville District Corps of Engineers established a small area office at Patrick Air Force Base in May of 1950 and awarded a contract for the construction of the first launch pad at the Cape. The launch pad (Pad 3) was completed by June of 1950. During the following month, the Army used the pad to launch the first missile (Bumper 8) from Cape Canaveral.

The Canaveral area office of the Corps under the Jacksonville District supervised and inspected $1.7 million in construction work and $.7 million in road contracts in the six months after the Bumper launch. During the next three years, contractors constructed facilities for testing of cruise-type missiles such as the Matador, the Snark and the Bomarc. The Air Force test-launched these missiles from Complexes 1 through 4. These complexes were located in an area northeast of the lighthouse at the point of the Cape. Other structures built in the area around this time included a communications building, a water plant, a fire station and several camera tower roads. Tracking stations, an administrative area, and a bivouac area were built just northwest of this point. A skid strip was constructed in the center of the Cape and more camera tower roads, a guidance station, sky screen stations, a fuel storage area, a tracking station, a transmitter building, headquarters, and a guard house were built south of the launching pads.

The construction of Port Canaveral, a deep-water port located at the south end of the Cape, began in July 1950 and continued through 1952. The Corps of Engineers carried out the dredging of the port. Ships delivered missile components at Port Canaveral and the Navy docked and serviced its tracking ships and missile launching submarines there as well.

In August of 1961, the National Aeronautics and Space Administration (NASA) and the Department of Defense chose a section of Merritt Island (across the Banana River, three miles west from Cape Canaveral) as the launch center for the Manned Lunar Landing Program. This would be the site of the John F. Kennedy Space Center, owned and operated by NASA. During the period of the land acquisition and development, NASA built and modified a number of existing Air Force launch and support facilities at Cape Canaveral to carry out manned and unmanned space programs.

A new period of construction began at Cape Canaveral in 1962 when the Air Force began its Titan III program at the installation. Due to safety considerations and area size requirements, Air Force contractors constructed facilities for this program on dredge spoil in the Banana River about a mile from the west side of the Cape. New missile handling technology, engineering, and launching techniques characterized the Titan III Program. Utilizing a concept known as Integrate-Transfer-Launch (ITL), the new Titan III facilities allowed for off-pad assembly of the missile, integration of the boosters, payload checkout and rail transport to one of two launching pads, all while the missile was in a vertical position. The ITL approach enabled the Air Force to obtain a high launch frequency without requiring additional launch pads. The Titan III facilities, completed in 1964, included two launch complexes (40 and 41), special assembly buildings (including the Vertical Integration Building), and the first rail line at Cape Canaveral.

By 1966, activities at Cape Canaveral had reached their peak and in the years following there was a gradual decline in operations. Most of the activity had shifted to the Kennedy Space Center in conjunction with NASA’s effort to land a man on the moon. The Air Force deactivated or put on standby the launch complexes and support buildings at Cape Canaveral that had served their purposes and were either not adaptable to other uses or not maintainable for economic reasons. Facilities transferred to NASA during the early 1960’s were gradually transferred back to the Air Force.

By the late 1960’s, there were three primary launching zones at Cape Canaveral. Located on the eastern point of the Cape were complexes 1, 2, 3, 4, 21/22, and 43. Except for Complex 43, which supported weather rocket launches, these complexes had generally been used for various winged missile programs (such as Snark, Bomarc, Matador, Bull Goose, and Mace). North of this point were eleven complexes situated in a line following ICBM Road. These complexes supported Atlas, Titan, and Saturn launches. Complexes 5/6, 9, 10, 17, 18, 25, 26, 29, 31, and 32 were located south of the Cape’s eastern point. These sites had been built to support Redstone, Navaho, Thor, Blue Scout, Vanguard, Polaris/Poseidon, and Minuteman launches.

2.4 Overview of Missile Testing at Cape Canaveral

Designs for long-range missiles generally fall into two basic categories: aerodynamic cruise, or "winged" missiles; and the more advanced ballistic missiles. Cruise missiles, resembling unmanned airplanes, require oxygen to support engine combustion and are therefore restricted to the Earth's atmosphere. Ballistic missiles, on the other hand, carry their own oxygen source allowing them to travel beyond the earth's atmosphere. Faster and more effective than cruise missiles, ballistic missiles travel in long arcing trajectories before striking their targets. Ballistic missiles themselves are further divided into several basic types: the short-range ballistic missile with a range of up to 200 miles, the intermediate-range ballistic missile (IRBM) with a range of up to 1,500 miles, and the intercontinental ballistic missile (ICBMs) with a range up to 5,000 miles.

2.5 Early Missile Research and Development

While the Army was beginning to test launch captured German V-2 rockets at the White Sands Proving Ground in 1946, the Army Air Force (the immediate predecessor of the Department of the Air Force, established in 1947) began funding its first long-range missile development studies. In January of that year, engineers from the Consolidated Vultee Aircraft Corporation (Convair) presented the AAF with two design proposals for a missile capable of carrying a 5,000 pound warhead over a range of between 1,500 and 5,000 miles. One design was for a cruise missile and the other for a ballistic missile. AAF officials awarded Convair a study contract in April 1946. Headed by the Belgian-born engineer Karl Bossart, the Convair effort became known as Project MX-774. To collect the necessary data, Bossart gained permission to build ten test vehicles. Funding cutbacks soon forced Bossart to abandon the cruise missile design and concentrate solely on the ballistic missile design. Bossart and his team concentrated their efforts on improving the structural design and performance of the German V-2 rocket but continued funding cutbacks forced the cancellation of the program in July 1947. Even though funding for the project was terminated, the AAF allowed Bossart and his team to use their remaining unexpended funds to complete and flight test three vehicles. These flight tests, conducted at the White Sands Proving Ground between November 1947 and May 1948, validated Bossart's design changes. Later ballistic missile programs benefited from information gained during this project.

In the late 1940s, the United States drastically reduced its defense spending as the nation adjusted back to a peacetime economy. The reductions forced the Air Force to decide between developing either long-range cruise missiles or long-range ballistic missiles. Air Force officials decided to pursue development of cruise missiles on the grounds that this type would become operational sooner than the expected ten-year time frame necessary for the development of an operational ballistic missile. In the late 1940s and early 1950s the Air Force began to invest heavily in the development of several cruise missiles. These included the Matador, Snark, and Navaho missiles. The Army, meanwhile, continued its work with the V-2.

2.6 Early Missile Testing At CCAFS

The Army was the first service to conduct a missile launch at Cape Canaveral. The missile was Bumper No. 8, a captured German V-2 rocket with a WAC Corporal second stage. The launch took place on 24 July 1950 at Complex 3. An Army-General Electric Corporation team launched the rocket under primitive conditions, fueling the rocket directly from tank trucks and launching from a temporary wooden blockhouse surrounded by sand berms. The rocket, whose primary mission was to prove the feasibility of separating stages while in flight, traveled about 190 miles down the range. A second and final Bumper launch was undertaken five days later.

Bumper 8 launch at Cape Canaveral (NASA)

Aside from the Army Bumper launches, the majority of launches at Cape Canaveral in the early 1950s were Air Force winged missile launches. The first Air Force launch at the Cape occurred on 25 October 1950 when a team launched a Lark interceptor missile. The Lark had first been used by the Navy against Japanese aircraft during World War II. The Air Force's Lark flight lasted less than two minutes and covered only one mile. The Air Force continued to launch Larks at the Cape until August 1953.

The tactical Matador winged missile was the first Air Force missile program to become operational after being tested at Cape Canaveral. It was also the first missile to be successfully tracked by the downrange station on Grand Bahama Island. The Air Force conducted the first Matador launch from the Cape on 20 June 1951. Over the next ten years, the Air Force conducted a total of 286 Matador launches.

The Air Force's Snark missile was a surface-to-surface pilotless bomber with a range of over 5,000 miles. It was the first and only long range intercontinental winged missile. Launched from Complexes 1 and 2 between 29 August 1951 and 6 December 1960, the Snark made 98 downrange flights, including 3 'dummy' Snark flights. Although the Snark was the first missile to be tracked by the downrange stations at Antigua and Ascension islands, many of the Snark flights were unsuccessful, ending up in the Atlantic Ocean. Despite the many mishaps during testing, the Snark achieved a number of "firsts." These included being the first missile to return and land at Cape Canaveral's skid strip, a runway constructed in the early 1950s to allow a guided missile to be launched from the Cape, fly a trip down range, return and land upon mission completion. In addition, the Snark was the first missile to be equipped with a ballistic nose that separated from the missile and fell on its target, and the first missile to use a stellar guidance system.

In August 1955, the Air Force began the test phase of its Navaho program at Cape Canaveral. The Navaho was a surface-to-surface missile intended as an intercontinental strategic weapon. Launched from the skid strip or from Complexes 9 and 10, the Navaho was carried aloft, piggyback fashion, by a liquid-fueled booster. The Navaho test program continued through January 1959. Although the Air Force eventually canceled the program, the Navaho pioneered the development of inertial guidance systems and large rocket engines.

Other winged missiles tested by the Air Force at Cape Canaveral included the Mace, the Bomarc and the Bull Goose. The Mace, an improved version of the Matador, made 44 flights from Complexes 21 and 22 from 29 October 1959 through 17 July 1963. The Bomarc and the Bull Goose were defensive winged missiles. The Bomarc was designed to intercept and destroy enemy aircraft and the Bull Goose was a diversionary missile designed to confuse enemy air and ground forces. The Air Force first launched the Bomarc from Complex 4 in September of 1952. The Air Force tested the Bull Goose at Complexes 21 and 22 between March of 1957 and December of 1958.

2.7 United States Ballistic Missiles

In the early 1950s, the US Congress began to reassess the military cutbacks of the late 1940s. As US troops fought in Korea, Congress increased funding for military projects. The Air Force took advantage of the increased funding and initiated a long-range missile study, contracting Convair to carry out the effort. Designated Project MX-1593, this effort later became known as Project Atlas, a ballistic missile development project. The Air Force began funding further studies of the Atlas ballistic missile design in 1952. This funding, however, remained very low compared to the funding for the Air Force's cruise missile programs.

While the Air Force Atlas ballistic missile program proceeded slowly, the Army was making significant progress in ballistic missile development. The Army had moved its team of German scientists working at White Sands to the Redstone Arsenal in Huntsville, Alabama in 1950. This team developed the Redstone missile. The Army began testing the Redstone at Cape Canaveral in 1953, the first launch occurring on 20 August at Complex 4. The Army continued launching Redstones at Cape Canaveral throughout the mid-1950s. In 1956, the Redstone became the first ballistic missile to be deployed in the field by US troops and in 1958 the United States placed the Redstone in the North Atlantic Treaty Organization (NATO) arsenal.

Although the Redstone was a ballistic missile, it had a maximum range of only 200 miles and served merely as an extension of the Army's artillery. The Department of Defense desperately desired a long-range missile that could reach Soviet targets when launched from US soil. Early ICBM designs, however, called for giant, impractical missiles. These designs were based on the thrust requirements necessary to loft the heavy atomic warheads being produced at the time. Even if such a missile could be produced, considerable gains in guidance system technology would be necessary to make the missile accurate enough to be effective. Several important developments in the early 1950s, however, significantly impacted on ballistic missile design requirements. The first was the detonation of the world's first thermonuclear device by the United States in 1952. This event paved the way for development of the powerful hydrogen bomb. Soon after the detonation, the Atomic Energy Commission (AEC) predicted that the production of smaller nuclear warheads with tremendous destructive potential would soon be feasible. Smaller, yet more powerful warheads would solve many of the problems associated with missile weight and would also eliminate the need for pinpoint accuracy. This news, combined with intelligence reports indicating that the Soviet Union was making significant progress in developing both long-range missiles and thermonuclear warheads, prompted a reexamination of the United States' strategic missile programs.

The Air Force convened a panel of leading US scientists in 1953 to examine the Snark, Navaho, and Atlas missile programs. In February 1954, the panel, known as the Teapot Committee, submitted a report recommending the relaxation of performance requirements for long-range missiles (based on the new, lightweight, high yield thermonuclear weapons) and the acceleration of Atlas ICBM development. These recommendations received the approval and support of high ranking civilian and military leaders during the following months. Air Force officials, and in particular Trevor Gardner, Special Assistant for Research and Development, began campaigning vigorously to convince Congress and the President of the urgency of ICBM development. These efforts paid off in 1955 when President Eisenhower assigned highest national priority to the ICBM development program.

Air Force officials originally hoped to achieve operational capability with the Atlas by 1960. As a hedge against failure in the Atlas program, however, the Air Force initiated a second ICBM development program in 1955. This alternate ICBM became known as the Titan. By 1958, the Air Force began funding development of yet another ICBM, the Minuteman. The three-staged Minuteman was a solid-fueled ICBM designed for instantaneous launch from a heavily protected underground silo.

As the pace of the Air Force ICBM program quickened, intelligence reports indicated that by 1960 the Soviet Union would likely have a number of operational ICBMs armed with nuclear warheads. Fearing the United States would not be ready to match that threat, Department of Defense officials decided that an IRBM should be developed and based in Europe to act as a stopgap measure until a sufficient number of American ICBMs became operational. After it was concluded that an IRBM with a 1,500 mile range could be developed in a relatively short time, the Joint Chiefs of Staff granted approval in 1955 for two IRBM programs - the Air Force Thor IRBM program and the Army/Navy Jupiter IRBM program. Both programs advanced simultaneously, in direct competition with each other.

2.8 IRBM Programs

The Army was the first service to test launch an IRBM at Cape Canaveral. This occurred on 14 March 1956 when a modified Redstone with Jupiter components lifted off the pad at Complex 6. The first Jupiter IRBM launch occurred at Cape Canaveral one year later. Between March of 1956 and January 1963 a total of 63 Jupiter launches occurred at Launch Complexes 5/6 and 26. These launches were conducted by both the Army and NASA (after the latter's establishment in 1958), and included test launches of the Jupiter-A and the Jupiter-C developmental series.

The Jupiter IRBM became operational in 1960. Although developed by the Army, it was the Air Force that actually gained operational responsibility for the weapon system. This situation came about in November 1956 when Secretary of Defense Charles Wilson issued a memorandum that divided responsibilities for research and development of ballistic missiles among the armed services. Wilson restricted the Army to developing weapons with ranges of 200 miles or less. At the same time, Wilson assigned sole responsibility for the development and deployment of IRBMs and ICBMs to the Air Force. The Navy received responsibility for developing ship-based IRBM systems. The Army completed the development of the Jupiter IRBM and then turned it over to the Air Force for deployment. The Air Force had operational Jupiter IRBM squadrons in Italy and Turkey by mid-1962.

Aerial view of 'Missile Row' at Cape Canaveral Air Force Station (NASA)

The Navy initially took part in the development of the Jupiter IRBM with hopes of converting the missile for use on submarines. However, the Navy eventually determined that the liquid fuels of the Jupiter were too volatile and unpredictable to be carried aboard a submarine. In 1956, the Navy withdrew from the Jupiter project and began developing the solid-fueled Polaris IRBM. The Polaris was designed to be launched from submarines whether the submarine was surfaced or submerged. The Polaris program began at Cape Canaveral in 1957 with the construction of Launch Complex 25. While construction of Complex 25 was underway, the Navy conducted its first Polaris launch at the Cape at Complex 3 on 13 April 1957. The first launch at Complex 25 occurred on 18 April 1958. The Polaris became operational in 1960 although the Navy continued testing versions of the missile at Cape Canaveral through the 1970s. In 1968, the Navy began testing its second generation Poseidon Ship-Launched Ballistic Missile (SLBM) at Cape Canaveral and in 1978 the Navy began its Trident SLBM program at Cape Canaveral.

The Air Force Thor IRBM program began at Cape Canaveral in 1956 when the Air Force initiated construction of Complexes 17 (later Thor launches also took place at Complex 18, Pad B). The first Thor launch occurred at Cape Canaveral on 25 January 1957 at Complex 17. Unfortunately, the missile exploded and burned on the pad. Three more mishaps followed until finally, on 20 September 1957, the Thor completed a fully successful test launch. The Air Force conducted the research and development testing phase of the Thor program at Cape Canaveral and the operational testing phases of the program at Vandenberg Air Force Base, California. Such was the case with the Air Force Atlas, Titan, and Minuteman ICBM programs as well. The Thor became operational in May of 1960. By the end of that year, the Air Force had deployed four squadrons in England with the Royal Air Force. The Air Force began to phase out these Thor squadrons in 1962 and 1963 as its Atlas and Titan ICBM sites became operational. Because of its reliability and versatility, the Thor continued in service as the booster for a wide variety of space missions.

2.9 Intercontinental Ballistic Missiles

At the same time the Air Force was developing its Thor IRBM, it was also making significant headway in its ICBM programs. The Atlas research and development testing program began on 11 June 1957 at Cape Canaveral. The Air Force conducted Atlas test launches at Complexes 11, 12, 13, and 14 through 1962. During the course of the Atlas program, the Air Force tested several models of the missile. These models were designated series A through F. The Air Force eventually stationed the D, E and F models, equipped with warheads and inertial guidance systems, at bases around the country as part of the United States' national defense arsenal. At one point, a total of 129 Atlas ICBMs were on strategic alert. The Air Force phased out its Atlas arsenal in 1964 and 1965 following the development of the Titan II and Minuteman ICBMs. Similar to the Thor, the Atlas also remained in service as a booster for America's manned and unmanned space missions.

The Air Force first tested its Titan ICBM at Cape Canaveral on 6 February 1959. Twenty of the first twenty-five Titan launches were completely successful. The Air Force declared the Titan ICBM operational in December of 1961 and by the end of 1962, six Titan squadrons were operational at five western Air Force bases. The first launch of the Air Force's second generation Titan, the Titan II, occurred on 16 March 1962 at Cape Canaveral. The Titan II, America's largest ICBM, was capable of carrying a heavier load than Titan I, used an inertial guidance system rather than a radio guidance system, and had the capacity to be launched from a silo. The Air Force declared the Titan II operational in December of 1963. Titan II was deployed at three Air Force bases and was also used as the booster for Project Gemini. The Air Force tested both Titan I missiles at Complexes 15, 16, 19 and 20 and Titan II missiles at Complexes 15, 16 and 19. The Air Force also developed the Titan III, albeit not as a weapon system but as a standardized launch vehicle for space programs. The Air Force first launched its Titan IIIc vehicle on 18 June 1965. The Air Force used Complexes 40 and 41 (Complex 41 is located at the Kennedy Space Center) for the Titan III development program.

Liquid propellants fueled most of the early weapons systems developed at Cape Canaveral. The Minuteman, the first multistage solid-fueled ICBM, was designed around the concept of instantaneous response to enemy attack. It was lighter, smaller, simpler and less expensive than the Atlas and Titan ICBMs. The Air Force eventually developed and test launched three versions of its Minuteman ICBM. Complex 31 hosted the first Minuteman launch on 1 February 1961. The Air Force test launched its Minuteman I, II and III ICBMs at Complexes 31 and 32 at Cape Canaveral through December of 1970. The Air Force first deployed Minuteman ICBMs at its bases in 1962. These missiles eventually became the backbone of the nation's strategic land-based nuclear missile force.

2.10 Beginnings of the United States Space Programs

The official beginnings of the United States space program can be traced back to 1955 when President Eisenhower announced that the United States would launch a small, unmanned Earth-circling scientific satellite as part of the nation's participation in the International Geophysical Year (IGY). While planning for the IGY late in 1954, the International Scientific Committee discussed satellite vehicles as a way of obtaining information about the upper atmosphere. The IGY provided a perfect opportunity for the United States to start a satellite program that would not appear to be motivated by military considerations. In reality however, military leaders in the United States were extremely interested in developing a military space program. Although the Air Force, Army, and Navy all had been conducting upper air research programs of varying magnitude, none of the services had initiated any major efforts to start a satellite program by the early 1950s.

President Eisenhower's announcement concerning the IGY prompted all three United States armed services to begin devising plans for a satellite program. By April, three separate plans had emerged. The first was a joint effort by the Army and Navy designated Project Orbiter. This plan called for placing a simple uninstrumented satellite into orbit utilizing an Army Redstone booster. A second plan by the Navy, eventually designated Project Vanguard, involved using a Navy Viking rocket as the first-stage of a three-stage rocket. The Air Force's plan recommended using an Atlas coupled with an Aerobee-HI second stage.

Faced with these three plans, the Department of Defense set up a special advisory group to review the proposed satellite programs and to make recommendations. Although favoring the use of the Atlas, the committee eventually decided that the Navy program had the best chance of placing the most useful satellite into orbit within the IGY without interfering with the priority of ballistic missile development. As a result, the Navy was given permission to proceed with its Project Vanguard.

Even after the Department of Defense advisory group announced their official support for the Vanguard program, the Army continued to push its own proposed satellite program. Although the proposal was continuously rejected, the Army Ballistic Missile Agency continued to claim it could launch a satellite on only four months notice. The Army's persistence would eventually pay off.

In August 1957, the Soviet Union announced that they had successfully launched a multistage long range ballistic missile that had reached a "very high, unprecedented altitude." The Soviets followed this launch with an even more impressive feat. On 4 October 1957, the Soviets shocked the world by placing Sputnik, the first man-made satellite, into orbit with one of their rockets. They quickly followed this launch with another the following month. On 3 November, a Soviet rocket placed the 1,120-pound Sputnik 2 satellite, carrying a live dog, into orbit. The Sputnik launches focused public attention on the United States' own fledgling missile and space programs. Reacting to the public furor created by the Sputnik launches, Congress increased funding for ICBM development while the Department of Defense pushed hard to match the Soviet feat by placing its own satellite into orbit.

While the Soviet's were successfully placing satellites into orbit, the Navy satellite program was experiencing many problems. The Vanguard launch vehicle blew up on its pad several times during a string of failed launch attempts. This was all the more embarrassing for the United States given the spectacular success of the Sputnik launches. While the Navy worked frantically to conduct a successful launch, the Army beat them to it. After the Sputnik launches, the Secretary of Defense gave approval to the Army to proceed with its satellite program. Eighty-four days later, on 31 January 1958, an Army team succeeded in placing the United States' first artificial satellite, Explorer I, into orbit using a modified Jupiter missile known as Juno I. This historic launch occurred at Complex 26. The Vanguard team finally succeeded in placing a satellite into orbit on 17 March 1958. The three-pound Vanguard I satellite, launched from Complex 18, studied temperatures and upper atmosphere conditions and also revealed the Earth to be slightly pear-shaped.

Launch of Explorer I, 31 January 1958 (NASA)

2.11 The Military Space Program

The Vanguard and Explorer launches were early efforts to place fairly primitive scientific satellites into orbit. The Department of Defense, however, gained valuable experience in satellite launch techniques as a result of these early efforts. Eager to build upon that experience, Department of Defense officials soon began planning the development of satellites that could be used specifically for military purposes. Although there had been interest among the armed services in developing reconnaissance satellites as far back as 1945, several obstacles delayed their development. Chief among these were the considerable technological challenges posed by achieving and maintaining orbit and the problems of data transmission.

Initially, the development of military satellites did not receive a high priority because the Department of Defense focused its attention on the development of operational long range missiles. By the mid-1950s, however, when it became clear that the Soviet Union would soon have numerous operational ICBM sites posing a threat to the security of the United States, American leaders quickly realized the importance of identifying the characteristics and location of those weapon systems. A 1956 study by the Research and Development (RAND) Corporation, partially sponsored by the Central Intelligence Agency (CIA), recommended that the Air Force undertake "at the earliest possible date completion and use of an efficient satellite reconnaissance vehicle as a matter of vital strategic interest to the United States."

In response to this study, the Air Force began calling for proposals from industry for the development of a photographic reconnaissance satellite. Two basic types of satellite systems were subsequently proposed.

One was a “non-recoverable” radio-relay reconnaissance system in which television cameras aboard a satellite would photograph ground targets, store the imagery on tape, and then relay the images to ground receiving stations when the satellite passed close enough overhead. The second type of satellite featured a “recoverable” system in which a capsule loaded with exposed film would be ejected from its satellite and return to Earth where it would then be recovered. The Air Force awarded the Lockheed Corporation a contract to develop both types of satellites in October 1956. The project became known as WS-117L (Weapon System-117L).

By 1958, the National Security Council assigned highest priority status to the development of an operational reconnaissance satellite. In November of that year, the Department of Defense announced plans for its WS-117L program, revealing that it would consist of three separate systems: DISCOVERER, SENTRY (later called SAMOS), and MIDAS. The first two were reconnaissance systems and the latter was the nation’s first ballistic missile early warning satellite system. The Air Force conducted launches under these programs, using Thor and Atlas boosters coupled with various upper stages, throughout the 1960s and beyond. All of the DISCOVERER and SAMOS launches occurred at Vandenberg Air Force Base. Cape Canaveral supported two of the first three MIDAS launchings in February and May 1960.

The United States’ military satellite launchings did not go unnoticed in the Soviet Union. On several occasions the Soviets complained bitterly about the satellites. In light of statements by the Soviets on the illegality of such activities and the increasingly credible threat to shoot US reconnaissance satellites down, officials in the Kennedy administration decided to drastically curtail any official publicity concerning the United States’ military satellite programs. By 1962, all military launches were classified as secret. The national reconnaissance effort continued although henceforth it was conducted under the highest degree of official secrecy. Government officials hoped that the blackout of these activities would make it much harder for the Soviets to pick out the military satellites from among the various other nonmilitary application satellites the United States was launching. In addition, the Kennedy administration hoped that if the Soviet Union was not unnecessarily embarrassed in front of the other nations of the world, Soviet officials would not complain as loudly about the United States’ satellite reconnaissance activity.

By the mid-1960s, reconnaissance satellites were yielding a regular supply of photographs to officials in the military services and the CIA, allowing them to stay up to date with the latest Soviet military developments. By revealing that the Soviets did not have as many ICBMs deployed as US officials had previously thought, reconnaissance satellite photographs were greatly responsible for dispelling fears of the much publicized “missile gap.” Reconnaissance satellites also proved invaluable in monitoring compliance with international arms treaties such as the 1963 Nuclear Test Ban Treaty and the Strategic Arms Limitation Treaty (SALT).

2.12 United States Unmanned Civilian Space Program

Besides spawning the nation’s military space program, the early Explorer and Vanguard launches signaled the beginning of the United States’ civilian space science program as well. From these pioneering scientific launches evolved programs to study the Earth, the solar system, interplanetary space, the Moon, other planets and their moons, the galaxy, and ultimately, the universe. Besides enormously expanding our pool of scientific knowledge, these efforts greatly contributed to the nation's effort to send men safely to the moon and back. Information gained from the United States' various space science programs also has been applied toward practical ends, resulting in numerous application satellite programs. These application satellite programs have had a profound effect on the lives of a large proportion of the world's population.

NASA is the primary Federal agency responsible for civilian space programs. Other agencies, such as the National Science Foundation, the Department of Defense, and the Smithsonian Astrophysical Observatory, have specialized or complementary roles. After the Soviet Sputnik launches, President Eisenhower assigned temporary responsibility for the US space program to the Department of Defense. The Department of Defense subsequently established the Advanced Research Projects Agency (ARPA) in February of 1958. ARPA became, in essence, the first US space agency. The Eisenhower administration, however, envisioned this as only a temporary measure. The president was hoping to reach an agreement with the Soviet Union that would limit the use of outer space to peaceful purposes. Realizing that a US space agency headed by the military would jeopardize this goal, Eisenhower pushed for the creation of a civilian space agency.

The National Aeronautics and Space Act that became law on 1 October 1958 established NASA as the primary US space agency responsible for developing and carrying out a national space program. NASA was created with the expressed intent that its space program be directed toward peaceful pursuits. The new civilian agency was to carry out aeronautical and space activities except those associated with defense, which were the responsibility of the Department of Defense. In anticipation of conflicts between NASA and the Department of Defense, provisions were made for mediation between the two via the President and a newly formed National Aeronautics and Space Council.

Almost immediately, NASA initiated a National Launch Vehicle Program aimed at eliminating the proliferation and duplication of orbital launch vehicles. Consequently, five launch vehicle families evolved. These included the Scout, the Thor (which eventually evolved into the Delta), the Atlas, the Titan, and the Saturn vehicles. Separate complexes at Cape Canaveral supported launchings of these space boosters. The successful launch vehicle program enabled NASA and the Department of Defense to turn to each other for launch services whenever a certain payload better fit the other agency's launch vehicle, regardless of who sponsored the launch vehicle.

NASA's civilian unmanned space program consisted of both science and application satellite and space vehicle programs. Throughout most of the 1960's, these programs were under the direction of the NASA Office of Space Science and Applications. A reorganization within NASA in 1972 resulted in the separation of the science and application satellite programs with each given its own office headed by an associate administrator.

Many of the missions in NASA's space science program have been directly related to physics and astronomy. Although some of these missions have been suborbital, involving sounding rockets and balloons, and others have traveled as far as the Moon, the majority of NASA's physics and astronomy missions have been Earth orbital. The orbital missions have been especially rewarding to scientists because they allow measurements to be taken of phenomena well above the reach of sounding rockets or balloons. Orbital missions also have helped revolutionize astronomy by placing telescopes above the distortion caused by atmospheric turbulence and electromagnetic, infrared, and short-wave radiation. Explorer spacecraft and several more complex orbiting observatories, such as the Orbiting Solar Observatory (OSO), the Orbiting Astronomical Observatory (OAO), the Orbiting Geophysical Observatory (OGO) and the High Energy Astronomy Observatory (HEAO), provide NASA with its principal means of conducting long-term automated investigations of the Earth, interplanetary space in close proximity to the Earth, Sun-Earth relationships, and astronomical studies of the Sun, stars, and galaxies. Explorer missions, many of them undertaken with a significant degree of international cooperation, have been launched from both Cape Canaveral and Vandenberg Air Force Base using a variety of launch vehicles. Launches in the Explorer series began in 1958 and have continued into the 1990s. NASA launched all of its orbiting observatories from Cape Canaveral complexes in the 1960s and 1970s.

Major NASA programs involving investigations of distant interplanetary space, the Sun, the Moon, and the planets include Helios, Pioneer, Pioneer-Venus, Ranger, Surveyor, Lunar Orbiter, Mars, Mariner, Viking, and Voyager. In supplying scientists and technicians with invaluable information and images, the spacecraft associated with these programs have dramatically increased our knowledge and understanding of our solar system and beyond.

Besides purely scientific programs, the United States unmanned space program has also encompassed a multitude of application satellite programs. Too numerous to list here in detail, these application programs include communication satellites, meteorological satellites, Earth resources and environmental monitoring satellites, ocean sensing satellites, geodynamic satellites, and navigation satellites. Application satellites have had a tremendous impact on modern life. They have linked together remote areas of the Earth, exerted a lasting impact on the growth and application of the science of meteorology, and provided numerous new ways to examine and map the Earth and its oceans. Also, there has always been a close correlation between civilian and military application satellites, especially for communications, weather and geodesy. Application satellites characterized as "military" often provide useful information to the civilian sector while "civilian" satellites, in turn, often furnish important information to the military as well. The United States application satellite programs, combined with the nation's space science programs, have revolutionized the way we see our world and the way in which we live in it.

2.13 United States Manned Space Program

In April of 1961, Russian cosmonaut Yuri Gagarin rode the Vostock I into an orbit around the earth, becoming the first man to do so. This achievement shook American officials into action. On 25 May 1961, in a special message to Congress, President Kennedy stated that the United States "... should commit itself to achieving the goal before this decade is out, of landing a man on the Moon and returning him safely to the earth." Public support was widespread and Congress heartily endorsed the measure. NASA was responsible for carrying out the ambitious goal.

The American manned space program was divided into three phases: the Mercury, Gemini and Apollo programs. Cape Canaveral supported all of these phases. The goals of Project Mercury were to demonstrate that it was possible for a man to tolerate what it would take to send him into space and bring him back. These included withstanding the acceleration of rocket launches, adapting to long periods of weightlessness, and then withstanding the high deceleration period during reentry. Project Mercury had two parts, a suborbital stage and a manned orbital stage. During the first stage, NASA launched the chimpanzee, Ham, on a suborbital flight aboard a Mercury/Redstone vehicle on 31 January 1961. Other test launches utilizing primates followed. Alan Shepard became the first American man in space on 5 May 1961 when he rode aboard a modified Redstone rocket. Virgil Grissom's flight followed on 21 July 1961. NASA launched two manned Mercury suborbital flights from Complex 5/6. Other suborbital flights were launched from Complex 14.

Launch of Apollo 11, 20 July 1969 (NASA)

John Glenn became the first American man to successfully accomplish a manned orbital flight mission. He circled the earth three times aboard Mercury/Atlas 6 on 20 February 1962. Gordon Cooper's 22-orbit flight, ending on 16 May 1963, concluded Project Mercury. It was the fourth manned mission. The whole Mercury program lasted 55 months and led directly to Project Gemini.

NASA publicly announced Project Gemini on 3 January 1962. The goal of Project Gemini was to perfect space rendezvous and docking techniques and to attempt extravehicular walks in space. The successful completion and mastering of these operations was necessary to move on to the next step of landing men on the moon and then recovering them. Sophisticated manned space flight was mastered during this project.

NASA used a modified Titan II as the space booster for Project Gemini, and a Mercury capsule which was twice the size of earlier capsules was used to accommodate two astronauts. The first Gemini launch took place on 8 April 1964 from Complex 19. The first Gemini manned flight took place in March of 1965. There were a total of ten manned Gemini flights, placing 20 astronauts into orbit. These flights allowed the astronauts to conduct sophisticated maneuvering exercises and return back to earth safely.

The goal of Project Apollo was to send a three-man spacecraft into orbit around the Moon, land two of the astronauts on the Moon while the third continued to orbit, return the two men back to the orbiting spacecraft and then return all the men safely back to earth. NASA announced on 9 January 1962 that the Saturn V rocket would be the launch vehicle. The Saturn V was a huge rocket standing about 27 stories high and capable of generating 7.5 million pounds of thrust.

NASA divided Apollo into two phases: earth orbital (unmanned and manned) and lunar. Missions were designed to test spacecraft launch vehicles, equipment and crew procedures. Tragedy struck on 27 January 1967 when an oxygen fire at Complex 34 took the lives of astronauts Virgil Grissom, Edward White and Roger Chaffee, the first casualties of the US space program..

Despite the tragedy, the Apollo program continued. The first Saturn V test flight took place on 9 November 1967 with the launch of Apollo 4. The first manned Apollo launch took place on 11 October 1968 when Apollo 7 put three astronauts into earth orbit. The first lunar orbiting occurred during Apollo 8 in December of 1968. Finally, on 20 July 1969, Commander Neil Armstrong became the first person ever to set foot on the moon during the Apollo 11 mission. Six additional moon missions followed. Apollo 17, launched on 7 December 1972 was the last mission in the series. The Apollo launches took place at Complex 34 at Cape Canaveral and Complex 39 at the Kennedy Space Center.

2.14 Beyond Apollo

Three other manned space missions occurred after the Apollo program, all taking place at the Kennedy Space Center. The Skylab mission began on 14 May 1973 and involved placing a large inhabitable structure into orbit around the earth for use in collecting scientific data. Apollo-Soyuz was a cooperative project between the Americans and the Russians involving the docking of two manned spacecraft in space. NASA launched this project from Complex 39 at the Kennedy Space Center. NASA first launched the Space Shuttle, the world’s first reusable spacecraft, from Pad A at Complex 39 on 12 April 1981. Complex 39 continues to support Space Shuttle launches.

Section II

Missile Systems

AEROBEE

Associated Launch Complex

Launch Complex 47

Program Milestones

Development:	1946
First Successful Firing:	1947
Deactivation:	1985

Specifications (USAF Aerobee-150)

Service:	USAF
Category:	Sounding Rocket
Prime Contractor:	Aerojet
Length:	29 feet, 8 inches
Weight:	2,000 pounds
Diameter:	12 inches
Wingspan:	4 feet, 6 inches
Propulsion:	Solid boost/ liquid sust.
Speed:	Supersonic
Guidance:	Unguided
Range:	N/A
Altitude:	Up to 150 miles
Warhead:	N/A

The Aerobee Sounding Rocket (WSMR)

During 1945 the US Army Ordnance department developed plans for the testing and firing of a number of German V-2 rockets captured by the Allied forces at Peenemunde. The original objective was simple: to gain a better understanding of the German rocket and its military effectiveness. Several officers of the Army Ordnance Corps, however, recognized the potential scientific usefulness of such high-altitude firings and invited interested groups to provide research instrumentation that could be carried in the otherwise inert 'warhead' of the rocket. This invitation was enthusiastically accepted and the high-altitude research program was inaugurated with the first V-2 firing at White Sands Proving Ground (WSPG). At the same time, the Jet Propulsion Laboratory of the California Institute of Technology had developed the WAC Corporal missile. Several WAC Corporals had been fired during 1945, carrying 10 lbs of instrumentation to an altitude of over 200,000 feet.

There was a considerable demand for upper atmospheric research using rockets and, in 1946, it was decided to develop a rocket that would be capable of carrying 150 lbs of instruments to an altitude of at least 265,000 feet. In May 1946, Aerojet Engineering Corporation was awarded the contract for what was to become the Aerobee sounding rocket. The name 'aerobee' derives from the first four letters of the contracting company

Aerobee ready for launch (KSC)

with the suffix from the Bumblebee family of missiles of the Applied Physics Laboratory (APL) of Johns Hopkins Universoty. APL was responsible for the technical direction of the work. Development of the Aerobee was undertaken largely between June 1946 and November 1947. On 24 November 1947, the first successful range launch of an Aerobee rocket took place at White Sands Missile Range, New Mexico.

The Aerobee was designed as an expendable ballistic rocket capable of transporting a scientific payload to extremely high altitudes. It was a two-stage vehicle using a solid propellant booster and a liquid fuel sustainer. The Aerobee had no guidance system. To minimize impact dispersion due to the effects of surface and lower-atmospheric winds, the Aerobee rocket was launched from a tower approximately 150 feet high. These launching towers sat upon a tripod that had one hinged leg, and two hydraulically powered legs for extension or retraction. This rendered the tower adjustable and allowed the launching angle to be modified according to the wind conditions and thereby further reduced the impact dispersion. An interesting feature of the Aerobee was that the rocket did not follow a normal ballistic flight path, but continued straight up until reaching its zenith and then fell tail first back into the denser atmosphere. The rocket then inverted and continued its descent in a normal ballistic trajectory. At the zenith of the flight the nosecone, carrying the scientific payload, separated and returned to Earth with the aid of a parachute.

On 22 May 1952, two Philippine monkeys and two white mice were enclosed in an Aerobee nose section at Holloman Air Force Base, New Mexico. The rockets reached an altitude of 36 miles and a speed of 2,000 mph. The section containing the animals was later recovered. This historic flight provided valuable information on the physiological effects of space travel, including the stresses caused by high acceleration and weightlessness.

The original Aerobee underwent constant modifications and improvements. The design and development of the Aerobee-Hi began in 1952, when the Air Force and the Navy began cooperating with the Aerojet Corporation to improve the standard Aerobee rocket. The general idea was to maintain the basic Aerobee design but improve the rocket's mass ratio, increase the efficiency of the thrust chamber and add more propellant. Two versions of this high performance rocket were developed by the Aerojet Corporation; one for the United States Air Force and one for the United States Navy. The Air Force Aerobee-Hi was capable of carrying a nominal payload of 150 lbs to an altitude of 145 miles. Using a minimum payload of about 120 lbs, this rocket is capable of reaching an altitude of 160 miles. The

Navy version of the Aerobee-Hi was capable of carrying a nominal 150 lb payload to an altitude of 170 miles, and a minimum 120 lb payload to an altitude of 180 miles. Both of these rockets were of basically the same design, although the Navy version carried more propellant. Other classifications include the Aerobee-150 (in use throughout the 1960s, 1970s and 1980s), and the Aerobee-170 (using a Nike booster). The Aerobee was retired from service in 1985

ARCAS

Program Milestones

First Successful Launch: 1959

Specifications

Service:	Various
Category:	Sounding rocket
Prime Contractor:	Atlantic Research Corporation
Weight:	65 pounds
Propulsion:	Solid
Guidance:	Unguided
Range:	N/A
Altitude:	40 miles
Warhead:	N/A

Arcas Launcher (AFSMM)

The Arcas (All Purpose Rocket for Collecting Atmospheric Soundings) rocket system was used to obtain high altitude meteorological information. The unguided rocket was launched from a barrel-like tube and the angle of launch could be easily adjusted for wind direction and speed.

Two versions of the Arcas rocket were built. One was strictly a meteorological rocket while the other, the Arcas-Robin, carried balloons aloft during radar tracking experiments. The first launch of an Arcas rocket occurred in July 1959.

ATHENA

Program Milestones

First Successful Launch: 1964

Specifications

Service:	Air Force
Category:	Research Vehicle
Prime Contractor:	Atlantic Research Corporation
Length:	50 feet
Weight:	16,000 pounds
Diameter:	2 feet, 7 inches
Wingspan:	11 feet, 1 inch
Propulsion:	Solid
Speed:	14,760 miles/hour
Range:	470 miles
Altitude:	186 miles
Warhead:	N/A

Athena Test Missile (AFSMM)

The Athena test missiles were developed to support the Air Force Advanced Ballistic Missile Reentry System (ABRES). The Athena was designed to simulate the reentry environment of an intercontinental ballistic missile (ICBM) and was one of the few examples of sustained interstate missile tests within the United States. The project was begun in February 1964 with the first of several hundred launches from Green River, Utah, to impact points in the US Army's White Sands Missile Range in New Mexico. The vehicle would reach altitudes of over 300 km and peak velocities of 6700 miles per second on a trajectory that would lead to impact approximately 470 miles from the launch point. By August 1965, 85 flights had been completed in a series of 149 that was to run to 1969.

Data obtained from Athena flights was used by the Army in the development of defense systems, and by the Navy and the Air Force in the development of the ballistic missile reentry systems used on the Titan, Minuteman, Polaris and Poseidon ICBMs.

ATLAS

Associated Launch Complexes

Launch Complexes 11-14, 36

Program Milestones

Development:	1955
First Successful Launch:	1957
Initial Operational Capability:	1959
Deactivation (Atlas F):	1965

Specifications (Atlas E)

Historical Designation:	SM-65
Service:	USAF
Category:	ICBM
Prime Contractor:	Convair
Length:	82.5 feet
Weight:	267,136 lbs (fueled)
Diameter:	10 feet
Propulsion:	Liquid
Speed:	Mach 22
Guidance:	All-inertial
Range:	6,400-9,000 miles
Altitude:	3,300 miles
Warhead:	Nuclear

Atlas with Mobile Service Tower (FAS)

In 1946, the Army Air Forces contracted the Consolidated Vultee Aircraft Corporation (Convair) to develop a subsonic and a supersonic surface-to-surface missile with a 1500-5,000 mile-range. The program for the development of a supersonic missile, known as Project MX-774, laid the groundwork for the development of the Atlas Intercontinental Ballistic Missile (ICBM). In January 1951, the Air Force established another study project with Convair for the development of an intercontinental rocket-powered missile with a minimum range of 5,500 nautical miles, a minimum speed of Mach 6 over the target, an accuracy with Circular Error Probable (CEP) of 1,500 feet, and capable of carrying an 8,000-pound nuclear warhead. In September of that year, Convair produced a design for a missile that would be 160 feet long and 12 feet in diameter. This missile was expected to require as many as seven rocket engines to generate the necessary thrust.

On 1 March 1954 a test explosion in the Marshall Islands demonstrated that lighter, more powerful warheads were possible. This revolutionized the ballistic missile program and resulted in some fundamental changes in basic missile requirements. In January 1955, a new missile design was suggested. The new configuration, designated the XSM-65, would be a 240,000-pound vehicle, powered by two engines (each delivering 135,000 pounds of thrust) and a sustainer engine capable of generating 60,000 pounds of thrust. The CEP of the new missile would be five nautical miles. The first operational version of the Atlas missile was designed according to these specifications.

In September 1955, President Eisenhower issued a directive assigning the highest national priority to the ICBM research and development programs, prompted by the fear of a supposed disparity in the nuclear missile forces of the United States and the Soviet Union, the so-called “missile gap.” Two years later, the successful launch of Sputnik created a real sense of urgency within the United States ballistic missile program. Money was poured into the program and meticulously plotted timetables were severely compressed. A concept of ‘concurrency’ was adopted in which missile development and the construction of launch support facilities were conducted simultaneously. This resulted in a number of problems as specifications and construction requirements constantly changed as missile development progressed. In general, however, this approach succeeded in shortening the deployment schedule.

The research program undertaken by Convair produced a series of prototype missiles used to test the various components and subsystems that would go into the final operational version of the missile. The Atlas A, Atlas B and Atlas C would culminate in the Atlas D, the first operational Atlas missile. The first successful launch of an Atlas D occurred at Cape Canaveral Air Force Station on 28 July 1959. The success of this and a subsequent flight, on 11 August, prompted the Air Force to schedule a test launching conducted by a Strategic Air Command (SAC) crew at Vandenberg Air Force Base, California. This launch was successful and as a result, on 9 September 1959, General Thomas S. Power, Commander-in-Chief, Strategic Air Command, the Air Force declared the Atlas ICBM to be operational. On 31 October 1959, the first American ICBM equipped with a nuclear warhead, an Atlas D, went on alert at Vandenberg Air Force Base, California.

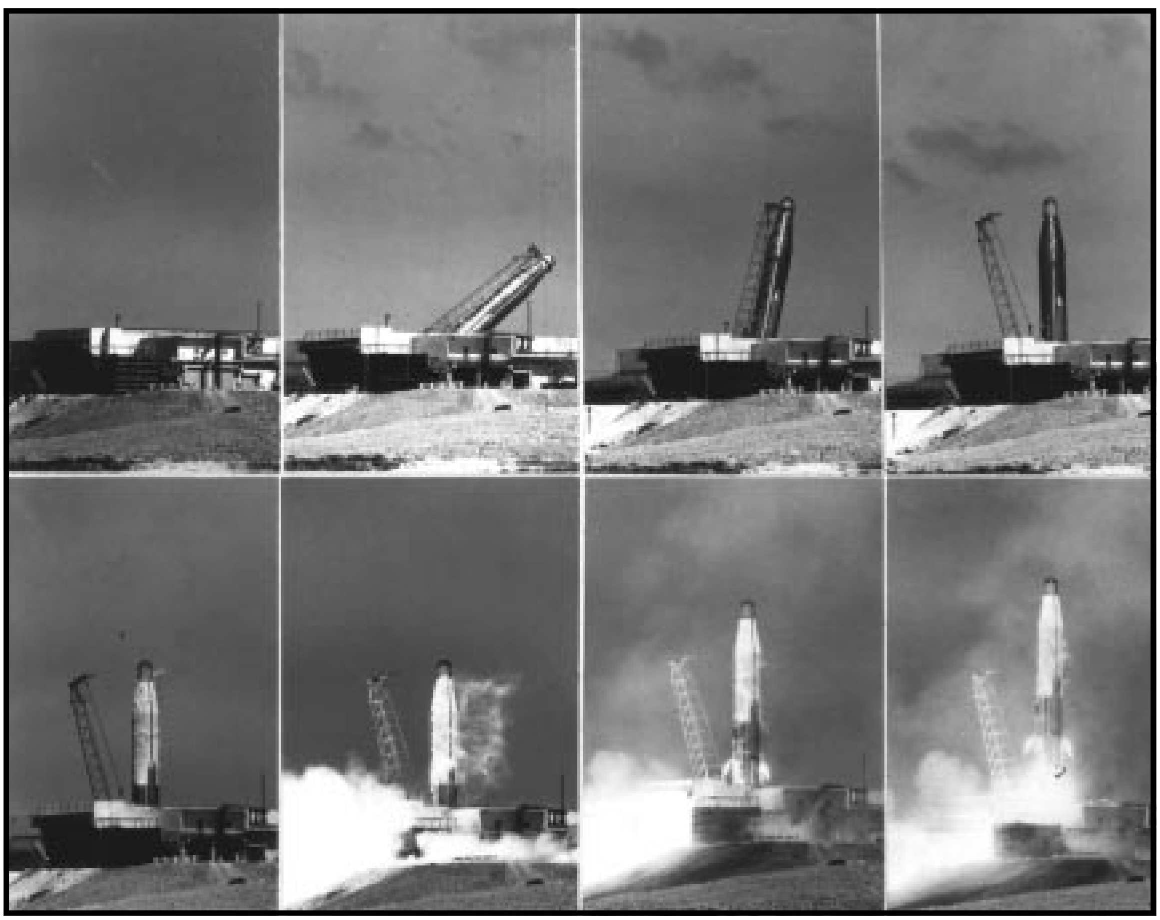
The Atlas D was followed by the Atlas E and the Atlas F. The first successful launch of an Atlas E took place on 24 February 1961 at Cape Canaveral and the first successful launch of an Atlas F took place at Vandenberg Air Force Base on 1 August 1961.

Launch of an Alas E (Spaceline)

By 1962, 13 Atlas D, E and F ICBM squadrons were activated across the United States. The launch emplacement and configuration varied according to the missile type. The Atlas D was launched from a typical gantry-type launch complex, with the missile standing above ground. The Atlas E used a ‘coffin-type’ launcher in which the missile was stored in a horizontal position within a protective, hardened, ‘coffin’ until just prior to launch. The missile was then raised to the vertical position, fueled and fired. The Atlas F ICBMs were stored in underground hardened silos and raised to the surface by elevator for launching.

The Atlas ICBM had a relatively short-lived operational existence, from 1959 to 1965. This was primarily the result of the increasing reliance upon the solid-fueled Minuteman ICBM. Economic considerations, however, also played a key role in the decision to deactivate the first generation liquid-fueled ICBMs. As early as 1963, an air staff study group recommended the retirement of the Atlas D and E, as well as the Titan I. The original schedule was for the Atlas D to be retired in 1965, the Atlas E in 1967 and the Titan I in 1968. After the elections of 1964, however, Secretary of State Robert McNamara announced "Project Added Effort" which called for the retirement of all first-generation ICBMs in 1965. It was estimated that this early phase out would save $117 million. The Air Force, recognizing that the Minuteman and Titan II ICBMs represented a safer and more flexible system than either the Atlas or the Titan I, made no effort to appeal the decision. The deactivation proceeded quickly and by July 1964, in the entire SAC inventory of 821 missiles, there remained only 113 Atlas missiles (18 Atlas D, 27 Atlas E, and 68 Atlas F) as against 600 Minuteman ICBMs. On 12 April 1965, the last Atlas ICBM, an Atlas F based at Lincoln AFB, was removed from alert status.

The Atlas was the United States' first operational intercontinental ballistic missile and, as such, provided the 'template' for later generations of ICBMs. This was certainly the case with regard to the scientific aspects of the program, with the



Atlas E launch sequence (FAS)

Atlas program paving the way in the development of guidance systems, propulsion systems, and airframe construction. The program also had a profound impact on American industry. In addition to the considerable injection of capital into the industrial sector resulting from the numerous government contracts, the more exacting manufacturing and testing requirements of ballistic missile components required the construction of entirely new and specialized facilities. Perhaps even more important, however, were the lessons learned concerning the manner in which such large-scale research and development programs should be organized and managed. In every respect, the development and production of the Atlas ICBM can truly be described as a pioneering achievement.

The Atlas Space Launch Vehicles

As Minuteman missiles replaced Atlas ICBMs in the late 1960s, the Atlas vehicles were withdrawn and converted for space launches. The Atlas D played its most important role as a space launch vehicle (SLV). The Atlas was paired with a variety of upper stages (most notably Agena and Centaur upper stages) and participated in nearly all of the most significant missions of the period. The manned Mercury missions used a modified Atlas D, redesignated LV-3B. Atlas-Agena combinations (LV-3A and SLV-3) were also used in the Ranger and Mariner programs and the Lunar Orbiter flights, while an Atlas-Centaur combination was used in the Surveyor lunar landing missions. The Atlas D was launched a total of 123 times, more than any other version of the Atlas.

The Atlas at the Cape

Cape Canaveral played an important role in the testing of the Atlas ICBMs and was also the site for many of the Atlas SLV launches. Construction of the first two Atlas launch pads, along with various support buildings, was completed at the Cape by the end of 1956. The first test launch of an Atlas A occurred on 11 June 1957. Unfortunately, the missile suffered an engine failure less than one minute after lift-off and the Range Safety Officer was forced to destroy it. Two more Series A missiles were launched from Pad 14 on 25 September and 17 December 1957, the latter being deemed a complete success. Throughout 1958, Pads 12 and 14 supported a series of Atlas A launches, with the last Atlas A launch occurring on 3 June at Pad 12.

The first Atlas B was launched from Pad 11 on 19 July 1958. The missile lost thrust 43 seconds into the flight, exploded and fell into the Atlantic about three miles from the Cape. Three Series B missiles were subsequently launched from Pads 13, 11, and 14 in August and September of that year. All of these achieved their test objectives. On 18 December 1958, in a launch known as Project Score, an Atlas B was launched into orbit from Pad 11. Its 122-pound payload consisted primarily of communications equipment designed to tape record radioed voice or code messages and rebroadcast them from the ground. The first words broadcast from space were those of President Dwight D. Eisenhower who relayed a Christmas message to the world:

> “This is the president of the United States speaking. Through the marvels of scientific advance, my voice is coming to you from a satellite circling in outer space. My message is a simple one. Through this unique means I convey to you and to all mankind America’s wish for peace on earth and good will toward men everywhere.”

The Atlas B was also used in the testing of the Mark II reentry vehicle, also known as the Heat Sink Nose Cone. The Mark II reentry vehicle was developed by General Electric in the late 1950s to overcome heat dissipation problems associated with missile reentry into the Earth’s atmosphere. This nose cone was designed to dissipate extreme heat within itself, rather than shedding layers of its skin like the Mark III and other more advanced reentry vehicles. The Mark II reentry vehicle was tested in a series of nine Atlas B flights from Cape Canaveral between 19 July, 1958 to 5 February, 1959.

The first Atlas C was launched from Pad 12 on 23 December 1958. Three more Series C missiles were launched from the same pad during the first half of 1959, including the first Atlas to carry a recoverable ablative nose cone (one that gradually eroded as it absorbed heat generated upon reentry). The last Atlas C was launched from Pad 12 on 24 August, 1959. The first Atlas D missile was launched from Pad 13 on 14 April 1959, and two more "D" series missiles were launched from Pads 14 and 13 on 18 May and 6 June. All three exploded less than 3 minutes after launch.

Launch of Friendship 7 (NASA)

The Atlas also participated in a number of important space programs at the Cape. On 20 February 1962, as part of the Mercury program, an Atlas booster paired with the capsule Friendship 7 was successfully launched from LC-14, placing astronaut John Glenn into orbit around the earth. The Atlas-Agena was one of the most successful launch vehicles at the Cape and was involved in numerous interplanetary missions. On 27 August a successful Atlas-Agena B launch from LC-13 sent a Mariner spacecraft on its way to Venus. Two years later, another Atlas-Agena B combination launched Mariner IV on its voyage to Mars. Atlas-Agena also enabled the collection of photographic images of the moon, serving as the booster for several successful launches in the Ranger and Lunar Orbiter programs. The Atlas-Centaur combination was used in the Surveyor program that landed a probe on the moon.

BLUE SCOUT

Associated Launch Complexes

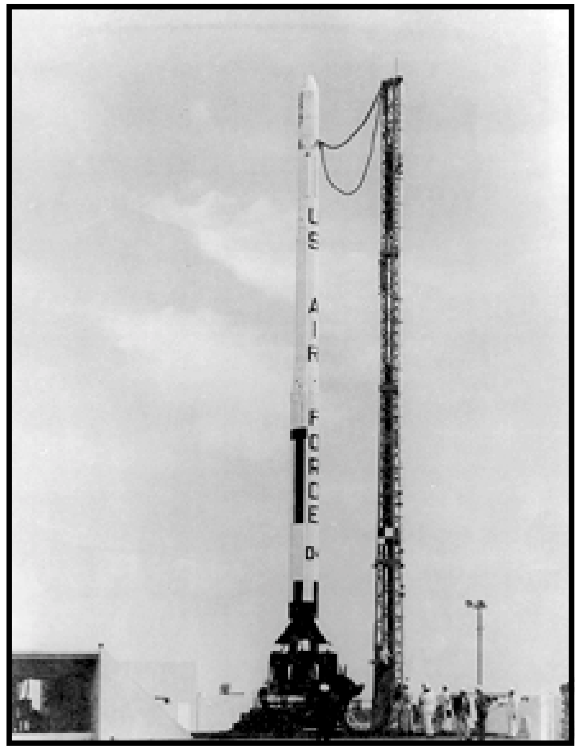
Launch Complex 18

Program Milestones

Development:	1959
First Successful Launch:	1960
Initial Operational Capability:	1963

Specifications (Blue Scout)

Historical Designation:	SLV-1A
Service:	USAF
Category:	SLV
Prime Contractor:	Chance-Vought Aero.
Length:	40 feet
Weight:	12,783 pounds
Diameter:	2 feet, 2 inches
Wingspan:	5 feet, 6 inches
Propulsion:	Solid
Speed:	14,000+ mph
Guidance:	Unguided
Range:	6,000+ miles
Altitude:	Upper atmosphere
Warhead:	N/A



Blue Scout Ready for Launch, Cape Canaveral (KSC)

The Scout (Solid Controlled Orbital Utility Test) launch vehicle was the first United States launch vehicle designed to use solid fuel exclusively. It was originally designed by Vought Astronautics as a booster for DOD, NASA and foreign space probes and orbital and reentry research payloads.

In the early days of the United States space program, the National Advisory Committee for Aeronautics (later known as the National Aeronautic and Space Administration, or NASA) needed a launch vehicle to investigate the possibilities of space flight. In 1958, the Scout program was approved by NASA. One year later, the Chance Vought Company received a contract for the design and development of the structural elements of the Scout vehicle and the launch tower.

At this same time, solid rocket motors were being developed for use with missile systems in other branches of the military. A cooperative agreement was entered into by these services with the Air Force and the Army and Navy both contributing their experience to the development of the Air Force Scout. The Scout first stage was derived from the Navy's Polaris missile, the second stage came from the Army's Sergeant missile, and the third and fourth stages derived from the Navy's Vanguard missile.

The Blue Scout is a USAF modification of the NASA Scout booster and is used as a space probe and satellite launch vehicle. There were three Blue Scouts in service: The Blue Scout Jr., the Blue Scout I and the Blue Scout II. The Blue Scout Jr. was a smaller version of the basic Scout vehicle and was commonly referred as 'the poor man's rocket' because of its relatively low cost of about $500,000.

The Scout at the Cape

Four versions of the Air Force Scout were designed for use at Cape Canaveral for orbital and suborbital missions. The first suborbital mission using a Blue Scout Jr. was launched on 21 September 1960. The first orbital mission was attempted in April of 1962. In 1961, the Air Force launched six Blue Scout I and II boosters from Launch Complex 18A. There were a total of ten Blue Scout Jr. launches at the Cape, including the last launch on 9 June, 1965.

BOMARC


Bomarc ready for launch, 1956 (Cleary)

Associated Launch Complex

Launch Complexes 3, 4

Program Milestones

Development:	1950
Production:	1957
Initial Operational Capability:	1959
Deactivation:	1972

Specifications (Bomarc A)

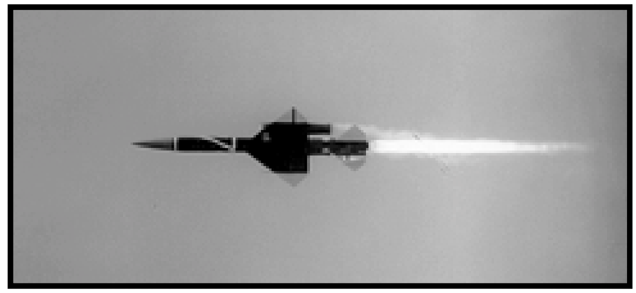
Historical Designation:	IM-99A
Service:	USAF
Category:	Surface-to-Air
Prime Contractor:	Boeing
Length:	45.25 feet
Weight:	15,000 pounds
Diameter:	2 feet, 11 inches
Wingspan:	18 feet, 2 inches
Propulsion:	Liquid, ramjets
Speed:	Mach 4
Guidance:	Radio Command
Range:	230 miles
Altitude:	60-80,000 feet
Warhead:	High explosive or nuclear

The Bomarc missile was a surface-to-air ramjet missile designed for area defense. It was developed by the Boeing Corporation and the Michigan Aeronautical Research Center and was named for these two entities (‘Bo’ from Boeing and ‘marc’ being the acronym for the Michigan Aeronautical Research Center). The Bomarc missile was intended to defend against an enemy air attack, either bomber or cruise missiles, and Bomarc launch sites were linked into a complex air defense warning system. The Bomarc-B (designated the IM-99B) was capable of carrying a nuclear weapon and could destroy entire formations of enemy aircraft. At launch, the Bomarc missile was propelled by a powerful rocket booster. Once it had reached a sufficient speed, ramjets took over the propulsion and powered the missile to its target. The Bomarc used a ground control guidance system until it had reached the vicinity of its target, at which time it came under control of an internal target seeker.

Testing of Bomarc prototypes began in 1952, with the first launch taking place on 10 September 1952. A series of subsequent launches took place throughout the 1950s, many of them at Cape Canaveral. In 1958, the Air Research and Development Command (ARDC) announced its plan to transfer the Bomarc program from Cape Canaveral to the Air Proving Ground Center's test site at Santa Rosa Island near Fort Walton Beach, Florida. The first Bomarc unit, the 4751st Air Defense Missile Wing, was activated on 16 January 1958 at Eglin AFB where it received training. The first Bomarc launch site was declared operational at McGuire AFB, New Jersey in 1959. The Bomarc was subsequently deployed at a number of sites in the United States, including bases in New York (Suffolk County AFB Long Island, Niagara Falls Municipal Airport), Massachusetts (Otis AFB), Maine (Dow AFB), Virginia (Langley AFB), Michigan (Kinross AFB) and Minnesota (Duluth Municipal Airport). In 1962, two Bomarc squadrons were placed under the Royal Canadian Air Force (RCAF).

Bomarc ready for launch, August 1952 (Cleary)

The improved Bomarc-B series became operational in 1961 and boasted an improved range (440 miles) and maximum altitude (100,000 miles). It also used more powerful ramjet engines and a solid propellant booster that permitted the nearly instantaneous launch of a missile on alert. By 1969, Bomarc-Bs were operational at six USAF sites in the United States and two RCAF sites in Ontario and Quebec. Between 1961 and 1965 Boeing delivered a total of 349 Bomarc-B missiles to the USAF. These either replaced aging



Bomarc in flight (KSC)

Bomarc A missiles at existing bases or were used for deployment at new sites. Bomarc-As were phased out in the mid-1960s, but beginning in 1962 some were modified and flown as supersonic, high altitude target drones (CQM-10a). Complete phaseout of the Bomarc's air defense mission was completed in October 1972.

The Bomarc at the Cape

Bomarc flight test operations began at the Air Force Missile Test Center (AFMTC) toward the end of June 1952, but equipment shortages combined with the late arrival of the missile, delayed the first launch until 10 September 1952. This launch took place from Launch Complex 4. After a considerable delay, the second Bomarc was launched from Cape Canaveral on 23 January 1953 with a third Bomarc flight following nearly five months later, on 10 June. Two more missiles were launched in the summer of 1953, but only three Bomarcs were launched from the Cape in 1954. In comparison with other aerodynamic missile programs of the period tested at the Cape, the Bomarc research program progressed rather slowly. By mid-1956 only eight propulsion test vehicles, nine ramjet test vehicles, and five guidance test vehicles had been launched.

Twenty-five more Bomarcs were launched from the Cape before the ARDC announced plans in September 1958 to transfer the Bomarc program to Santa Rosa Island. Between 10 September 1951 and 15 April 1960, a total of seventy Bomarcs were launched from the Cape.

BULL GOOSE

Associated Launch Complex

Launch Complexes 21, 22

Program Milestones

Development:	1955
First Successful Launch:	1957
Deactivation:	1958

Specifications

Historical Designation:	XSM-73
Service:	USAF
Category:	Ground-to-Air decoy
Prime Contractor:	Fairchild
Length:	33 feet, 6 inches
Weight:	7,700 pounds
Diameter:	2 feet
Wingspan:	24 feet, 3 inches
Propulsion:	Turbojet
Speed:	Mach .85
Guidance:	Inertial
Range:	500+ miles
Altitude:	50,000 feet
Warhead:	N/A

The Bull Goose missile (AFSMM)

The Bull Goose was a surface-launched decoy missile with an intercontinental range. Built by Fairchild, this air-breathing missile was powered by a J-83 turbojet engine. Flying at subsonic speeds, this missile was intended to confuse and saturate enemy air defense forces, thus allowing SAC bombers and missiles to reach their targets. Work on the concept started in December 1952, although USAF did not sign a contract with Fairchild until December 1955.

The Air Force planned to field 10 Bull Goose squadrons and to buy 2,328 missiles in addition to another 53 missiles that were to be used for research and development. The first squadron was to be operational in the first quarter of Fiscal Year 1961 and the last was scheduled to be operational the end of Fiscal Year 1963. The program was delayed, however, by a number of structural and funding problems.

The Bull Goose at the Cape

In the mid-1950s, a launch area near the Cape Canaveral Lighthouse was set aside to support the Bull Goose missile program. Construction began in 1956 and the Air Force accepted both complexes on 26 February 1957. At the same time, sled tests of the Bull Goose missile began at Holloman Air Force Base, New Mexico. The first Bull Goose missile was tested at Cape Canaveral on 13 March 1957 at the almost-completed Pad 22. Tests continued through 12 December 1958. While five tests in 1957 were successful, those in 1958 were less so. The USAF considered arming the Bull Goose, but canceled the program in early December 1958 because of budgetary pressures and because it was demonstrated that Fairchild's missile could not accurately simulate a B-52 on enemy radar.

CORPORAL

Associated Launch Complex

Launch Complex 3 (Bumper)

Program Milestones

Development:	1944
Production:	1951
Initial Operational Capability:	1954
Deactivation:	1963

Specifications

Historical Designation:	MGM-5A/M-2
Service:	Army
Category:	Surface-to-Surface
Prime Contractor:	JPL/Firestone
Length:	45 feet
Weight:	12,000 pounds
Diameter:	3 feet, 6 inches
Wingspan:	7 feet
Propulsion:	Liquid
Speed:	Mach 3.3
Guidance:	Command
Range:	75 miles
Altitude:	158,000 feet
Warhead:	Nuclear or conventional

Corporal Missile (WSMR)

The Corporal missile was the first surface-to-surface ballistic guided missile to be produced and made available to the Army Field Forces for tactical use in field operations. The Corporal missile system evolved out of the work being done in the 1940s by the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT). In January 1944 the Army Ordnance department requested that the California Institute of Technology undertake a research and development program on long-range, jet-propelled vehicles. The definitive contract for this program, known as the ORDCIT Project, was awarded in January 1945. Initial research aimed at producing an upper-atmospheric test vehicle and resulted in a series of prototype missiles, including the Private A, Private F, WAC Corporal and Corporal E.

In September 1949, after a comprehensive review of United States missile programs, the Corporal E was selected as the best candidate for development into the first US tactical guided missile. The start of the Korean War in June 1950 increased the pressure to transform the Corporal E into a missile with battlefield applications. The Corporal program, along with several other missile programs, was given a 'crash' status to accelerate the research and development and six months later, in December 1950, the Corporal was the first US missile to be approved as an atomic warhead carrier.

Corporal missile with launcher (Redstone)

The first version of this new tactical guided missile was identified as the Corporal Type I. Type I tests began in January 1951 and continued through December 1954. Most of the testing took place at the White Sands Proving Ground in New Mexico. These tests showed that the Corporal Type I missile system demonstrated serious deficiencies in terms of reliability and accuracy. As a result, on 7 October 1954, the Office, Chief of Ordnance (OCO), recommended that priority be given to the development of the new Sergeant missile system. At the same time, however, further testing revealed significant improvements in the Corporal Type I system and prompted the development of a Corporal Type II missile. On 4 April 1955, it was recommended that research support for a Corporal Type II be continued to ensure an interim missile capability in case a war broke out before the Sergeant missile system's expected operational capability date of 1961-62. Development of a Corporal Type III missile was also undertaken, but on a very limited basis and with limited funding so as not to interfere with the Sergeant program. On 23 May 1957 the Corporal Type III program was terminated.

The original objective for the Corporal program was to provide an operational capability of sixteen battalions in a state of combat readiness by July 1954. This goal was not achieved. By this date only three Type I Corporal battalions were activated. These three battalions, however, represented the first ballistic missile units to be activated in the United States. In February 1955 a Type I Corporal missile battalion, the 259th Battalion, was deployed in Europe, marking the first time that any United States missile battalion had been deployed overseas. In the Spring of 1956, the 259th Battalion was replaced in Europe by units equipped with Type II Corporal systems. Overall, some eight Corporal missile battalions, each composed of 250 soldiers and technicians, were deployed overseas. Each of these battalions included two batteries (a firing battery and a Headquarters service battery) with two operational launchers per battalion. Six of these battalions were stationed in Germany, and two battalion were stationed in Italy. Four Corporal missile battalions remained in the United States. In 1963, most Corporal battalions were deactivated and replaced by Sergeant missile units.

Early in 1955, the British government decided to integrate the Corporal missile into its field program, to provide a missile capability until such time as the British could design, test and produce similar weapons of their own. As a result, 113

Bumper 7 Launch at Cape Canaveral
29 July 1950 (Cleary)

Corporal missiles and several sets of guidance and handling equipment were ordered for the British Army. Later, British troops were brought to Redstone Arsenal and the Fort Bliss/White Sands area for technical training. The Corporal remained active in the British arsenal until 1966.

The WAC Corporal and the Bumper WAC Testing at the Cape

The WAC Corporal was a high-altitude sounding rocket developed for the Signal Corps in 1945-1946. In addition to permitting high-altitude research, the WAC Corporal also provided valuable information and engineering experience for future surface-to-surface missile programs including the Army's Corporal tactical missile.

Toward the end of 1946, the Army Ordnance Corps became interested in developing a two-stage rocket that would possess greater velocities and higher altitudes than single-stage rockets. To determine the feasibility of such a concept, a modified WAC Corporal B was mated to a German V-2 rocket booster. The resulting hybrid was referred to as a Bumper missile. The first of these missiles, Bumper 1, was launched from White Sands on 13 May 1948 and marked the first large, two-stage rocket to be launched in the western hemisphere.

A total of six Bumper missiles were launched at White Sands in 1948 and 1949. These tests demonstrated the feasibility of stage separation during vertical flight. Two more flights were planned with relatively low, flat trajectories of less than 150,000 feet, but the White Sands range proved too short to accommodate them. The Long Range Proving Ground at Cape Canaveral had the requisite length (250 miles) and in July 1950 Bumpers 7 and 8 were launched from the Cape. The Bumper 8 launch, which took place five days before the Bumper 7 launch when the latter was delayed due to a malfunction, represented a double first: it was the first missile to leave the then new Cape Canaveral launch complex, and was also the first recorded missile to undergo second stage separation and ignition during horizontal flight.

FIREBEE

Program Milestones

Development: 1940s
First Successful Launch: 1951

Specifications (Firebee II)

Service: Air Force
Category: Target Drone
Prime Contractor: Ryan Aeronautical

Length: 28 feet, 3 inches
Weight: 2,100 pounds
Diameter: 2 feet, 2 inches
Wingspan: 8 feet, 10 inches
Propulsion: J-69 Turbojet
Speed: Mach 1.5
Guidance: Radio Control
Range: 200 miles
Altitude: 50,000 feet
Warhead: N/A

Firebee II on display at the Air Force Space and Missile Museum (AFSMM)

The Firebee (I and II) was a remote-controlled target drone developed by Ryan Aeronautical. It was first flown by the Air Force in 1951. The Firebee could be launched from the ground or from the air and could attain speeds in the 600 mile per hour range. As the United States' most widely used remote controlled jet target drone, the Firebee flew thousands of missions at military bases throughout the United States, Canada and overseas installations.

Many Firebees possessed a parachute deployment system that allowed the missile to be reused. The Firebee drone distinguished itself for both its reliability and its economy.

FIREBIRD

Program Milestones

Development:	1946-49

Specifications

Service:	Air Force
Category:	Air-to-Air
Prime Contractor:	Ryan Aeronautical
Length:	9 feet, 5 inches
Weight:	263 pounds
Diameter:	6 inches
Wingspan:	3 feet
Propulsion:	Solid
Speed:	630 miles/hour
Guidance:	Radio
Range:	5 miles
Warhead:	High explosive

Firebird on display at the Air Force Space and Missile Museum (AFSMM)

The Firebird was one of the first US Air Force air-to-air missiles. Development began in early 1946 and flight tests were undertaken at Holloman Air Force Base, New Mexico between 1947 and 1949.

After being launched from an aircraft, the solid-fueled booster motor powered the missile in the early stages of its flight, providing 2,800 pounds of thrust. This booster was later dropped and four smaller solid-fueled motors, each providing 155 pounds of thrust, carried the Firebird to the target.

A limited number of Firebird missiles were manufactured and test-launched from F-82 jet fighters and B-26 twin engine attack bombers. The F-82 ‘Twin Mustang’ aircraft could carry two Firebird missiles under each wing.

HONEST JOHN

Program Milestones

Development:	1950
Production:	1951
First Successful Launch:	1951
Initial Operational Capability:	1953
Deactivation:	1982

Specifications

Historical Designation:	M-31/M-50
Service:	Army
Category:	Surface-to-Surface
Prime Contractor:	Douglas
Length:	27.3 feet
Weight:	5,900 pounds
Diameter:	30 inches
Wingspan:	8.7 feet
Propulsion:	Solid
Speed:	Mach 2.4
Guidance:	Unguided
Range:	21 miles
Altitude:	30,000 feet
Warhead:	Nuclear or conventional

Honest John rocket and launcher (Redstone)

The Honest John is a surface-to-surface, unguided, artillery rocket. The Honest John served as a direct support atomic weapon and was, in fact, the first atomic weapon carrier to be issued to ground combat forces. As originally envisioned, the Honest John was to be a simple, cheap, highly mobile and reliable free-flight rocket. It would not have any complicated electronic equipment and therefore would not require highly skilled operators or maintenance technicians. There was much skepticism concerning the feasibility of such a design, with critics arguing that such a simplistic design could never achieve the required level of accuracy. This skepticism directly contributed to the naming of the new missile system. Colonel Holger N. Toftoy, a former Redstone Arsenal Commander, was given responsibility for the naming of the missile. As Toftoy explained:

> "Before the test firing of the first 762mm rocket there was considerable controversy in the Pentagon as to its worth. In fact, there was serious consideration in the general Staff of cancellation [of the Honest John program] on the grounds such a large unguided rocket could not possibly have the accuracy to justify further expenditure

> of funds. At this time, on a trip to White Sands Proving Ground, we ran into a Texan making statements hard to believe. When his veracity was questioned, he exclaimed, 'Why around these parts I'm called 'Honest John'.' Feeling somewhat like the Texan at this time, I felt Honest John would be an appropriate nickname."

In 1950 Redstone Arsenal was assigned responsibility for a preliminary design study of a large-caliber free-flight rocket capable of delivering an atomic warhead. In June 1951 the first round of five feasibility demonstration flight tests were fired at White Sands Proving Ground to demonstrate that a large but simple unguided rocket could deliver a 1,500-lb payload to a range of 20,000 yards with acceptable accuracy. The results were a success. In August 1951 the Secretary of the Army issued verbal instructions to accelerate the development program. With the Korean War looming in the background, the Honest John program was put on a 'crash' basis, along with several other missile research and development programs such as the Corporal surface-to-surface guided missile, and the Nike Ajax anti-aircraft missile. In June 1952 the Douglas Aircraft Company was contracted to produce 50 Honest John prototypes. One year later a series of flight tests indicated that the basic Honest John system (designated M31) had satisfied all requirements and that production could begin. An improved Honest John missile system (M50) was later developed that reduced the missile's overall length and increased its range. The Improved Honest John replaced the basic system in 1961.

A particularly important issue was that of the support equipment for the Honest John missile system. An Honest John battalion had to be equipped with rugged, mobile launchers that were simple to operate. The ability to deliver atomic warheads ensured that the launchers would be prime targets for the enemy in the event of a war. To protect itself the battalion needed to possess a high degree of mobility so as to be able to adopt 'shoot and scoot' tactics. Using these tactics, the battery arrives at the designated firing area, fires the missile, and then immediately leaves the area to avoid enemy counterfire. There was considerable debate over what type of launcher would best fit these requirements. After much argument, a self-propelled, truck-mounted launcher was adopted.

Launch of Honest John rocket from mobile launcher (FAS)

Although placed on a crash basis in 1951, the Honest John missile system did not become available for deployment until six months after the Korean War had ended. In June 1954 the first eight Honest John batteries in the basic (M31) system configuration were fully equipped. In May 1961 the improved Honest John reached the field as a complete tactical unit. By the end of 1962, Army Artillery battalions both in the US and overseas were equipped with the improved Honest John and were fully operational.

But the Honest John was only intended as an interim emergency weapon and in May of 1964 the downgrading of the Honest John system from active to reserve status began. When the Lance system became operational, all Honest John equipment was to be converted to National Guard status. On 9 July, 1982 Honest John rocket motors, launchers and related ground equipment were classified obsolete

HOUND DOG

Associated Launch Complex

No specific Launch Complex

Program Milestones

Development:	1957
Production:	1958
First Successful Launch:	1959
Initial Operational Capability:	1960
Deactivation:	1975

Specifications

Historical Designation:	GAM-77, AGM-28
Service:	Air Force
Category:	Air-to-Surface
Prime Contractor:	North American Aviation
Length:	42 feet, 6 inches
Weight:	10,147 pounds
Diameter:	2 feet, 2 inches
Wingspan:	12 feet
Propulsion:	J-52 Turbojet
Speed:	Mach 1+
Guidance:	All-inertial
Range:	500+ miles
Warhead:	Nuclear

Hound Dog missile in flight (WSMR)

The Hound Dog, named after the Elvis Presley song, was designed as a long range, stand-off air-to-ground strategic missile. It was intended to extend the effective lethal radius of the B-52 bomber and improve its survivability while compounding the enemy defense problem. It was carried in pairs beneath the wings of B-52 aircraft. The overall mission of the Hound Dog was to aid B-52s in successfully carrying out a strategic bombing offensive. The Hound Dog would provide the B-52s with the capacity to attack and destroy heavily defended enemy targets, particularly those associated with air defense, without rendering the plane vulnerable and subjecting the B-52 fleet to unacceptable loss levels.

On 16 October 1958, Headquarters USAF awarded a Hound Dog production contract to North American Aviation, Inc. In the Hound Dog program, North American relied heavily on previous research done for the Navaho intercontinental cruise missile. Growing concern about the perceived unfavorable shift in the strategic balance and the increasing vulnerability of attacking bombers prompted USAF to accelerate the Hound Dog program.

On 23 April 1959 the first Hound Dog missile was air-launched from a B-52 aircraft flying over the Atlantic Missile Range. On 21 December 1959, General Thomas S. Power, Commander in Chief of the Strategic Air Command, formally accepted the first production model Hound Dog missiles in a ceremony conducted at North American Aviation's Downey, California plant. Headquarters Air Force finalized the Hound Dog missile program at the end of fiscal year 1959 when it approved a force of 29 B-52 squadrons equipped with Hound Dog missiles. The first launch of the missile from a B-52 took place in April 1959.

The guidance system for the Hound Dog missile was developed by North American's Autonetics Division and consisted of an inertial guidance system used in conjunction with a star tracker. The missile was not as accurate as could be desired and had a CEP exceeding one nautical mile at full range. It was decided, however, that this was sufficient given the four-megaton warhead carried by the missile. Reliability was another constant concern, as was the fact that the two five-ton missiles, mounted on pylons significantly degraded B-52 flight performance. A unique and useful feature of the Hound Dog missile, however, was that its engine could be used to supplement those of the B-52 to augment thrust either at takeoff or in flight. The missile could then be refueled from the host B-52 wing fuel tanks prior to its launch.

SAC launched its first Hound Dog in February 1960; and by the following July, one wing, the 4135th Wing of the Strategic Air Command was operational with the weapon. The numbers of Hound Dogs in the B-52 fleet rapidly grew from 54 in 1960, to 230 the following year, 547 in 1962, and 593 in 1963. Six hundred Hound Dogs were produced from 1957 to 1963. Twenty-three Hound Dog-equipped B-52 squadrons were operational by 30 June 1962, and by August 1963 29 SAC wings were operational with the missile. Hound Dog production ended in March 1963 and the number of operational missiles declined in the late 1960s and early 1970s to about 308 in 1976.

The Hound Dog was designed originally for a short three-year life span, and was intended to be replaced by the Skybolt air-launched ballistic missile. The Skybolt program was canceled in 1962, however, and the Hound Dog would stay in service for fifteen years until it was replaced by newer weapons. In 1972, SAC began deploying the Short Range Attack Missile (SRAM) and began phasing out the Hound Dog. The last Hound Dog missile was removed from alert on 30 June 1975. Nearly three years later, on 15 June 1978, the 42nd Bombardment Wing, Loring AFB, Maine, destroyed the last Hound Dog missile and removed it from the SAC inventory.

The Hound Dog at the Cape

The Hound Dog was tested at Cape Canaveral from 1959 to the early 1960s. There were no specific launch complexes associated with these missiles.

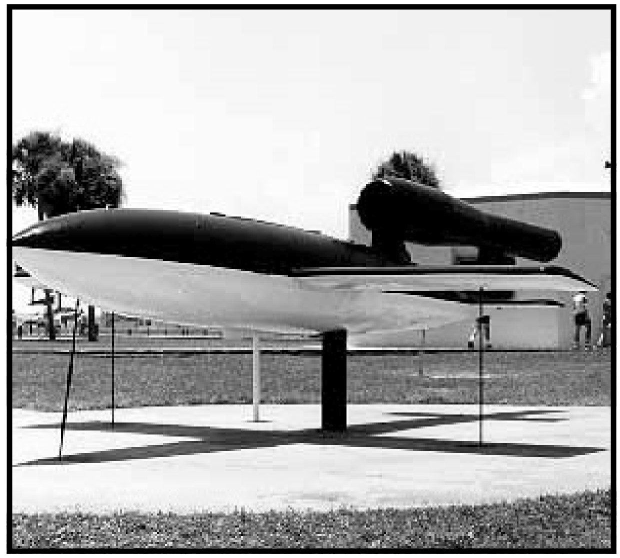
JB-2 'BUZZ BOMB'

Program Milestones

First Successful Launch:	1945

Specifications

Historical Designation:	JB--2
Service:	Army
Category:	Cruise / pilotless bomb
Prime Contractor:	Republic Aviation
Length:	23.6 feet
Weight:	5,021 pounds
Diameter:	2 .8 feet
Wingspan:	17.7 feet
Propulsion:	Pulsejet
Speed:	350-425 mph
Guidance:	Auto homing/radar
Range:	150 miles
Warhead:	High explosive



The JB-2 on display at the Air Force Space and Missile Museum (AFSMM)

On 12 July 1944, 2,500 pounds of salvaged V-1 parts were shipped from Great Britain to Wright-Patterson Field in Ohio. The Army Air Force (AAF) ordered the staff there to build 13 copies of the German "flying bomb." Within three weeks, the AAF had completed the construction of its first JB-2.

There was some resistance to the development and deployment of the new weapon. The War Department frowned upon the deployment of a "terror weapon" intended to target civilians and drew attention to the opportunity costs incurred, in terms of other armaments not produced and delivered, if the program went forward.

Despite these reservations, an order for 1,000 JB-2s was placed before the end of July. The AAF awarded contracts and the development program began. The JB-2 failed in its initial tests, but enthusiasm for the weapon grew rapidly. On 14 January, the wartime chief of the AAF placed an order for an additional 75,000 JB-2s. The next day the project was given an 'AA-1' priority level, the same level as that of the B-29 bomber.

This status was short-lived, however. Fears that such a production level would interfere with the production of artillery shells and heavy artillery pieces prompted criticism from both military and civilian sources. In late January the War Department decided not to mass produce the JB-2. Production continued at a more restrained level while the testing program proceeded.

The first attempted flight of a JB-2, on 12 October 1945, failed. Other attempts also ran into problems and by December, the success ratio stood at 20 percent (2 out of 10 attempts were successful.) This soon improved, and by June 1945, the AAF had achieved 128 successes in 164 attempts.

More than 12,000 JB-2's were produced. Although the "American V-1" was never used in combat, the testing and development program of the JB-2 provided invaluable information for the later design and construction of more advanced weapons.

JUPITER

Associated Launch Complexes

Launch Complexes 5, 6, 26A, 26B

Program Milestones

Development:	1956
Production:	1957
First Successful Launch:	1959
Initial Operational Capability:	1959

Specifications (Jupiter IRBM)

Historical Designation:	SM-78, PGM-19A
Service:	Army
Category:	IRBM
Prime Contractor:	Chrysler
Length:	60 feet
Weight:	108,804 pounds
Diameter:	8 feet, 9 inches
Propulsion:	Liquid
Speed:	Mach 15.1
Guidance:	All-inertial
Range:	1,500 miles
Altitude:	400+ miles
Warhead:	Nuclear

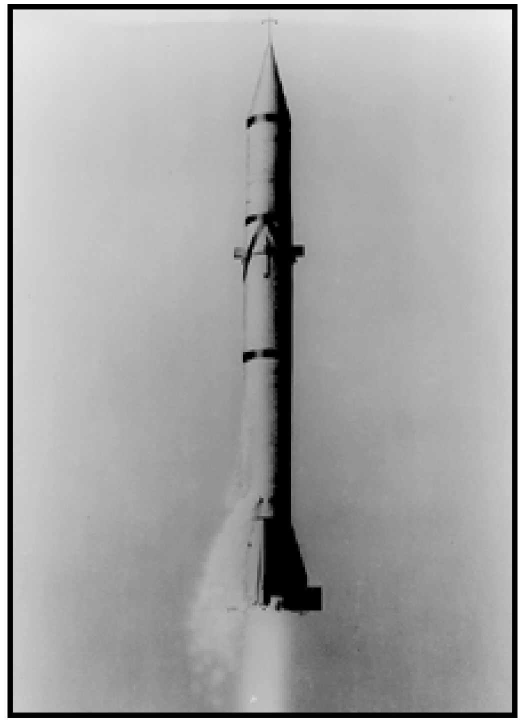
Jupiter IRBM (Spaceline)

The Jupiter missile, produced by Chrysler for the Army, was a single-stage, liquid-fueled rocket-powered ballistic missile equipped with an all-inertial guidance system. Stored vertically on field-deployed launchers, the Jupiter missile could be fueled and fired with only fifteen to twenty minutes notice.

On 8 November 1955, Secretary of Defense Charles Wilson assigned jointly to the Army and the Navy the development of an intermediate range ballistic missile (IRBM) with both a land-based and a shipboard capability. This joint responsibility for the development program proved troublesome, as the two services envisioned a somewhat different missile. The Army, for example, desired a large delivery system and its original proposal called for a missile that was more than 90 feet in length. The Navy, on the other hand, required a weapon that was as short as possible. As a result, the Army and Navy compromised, agreeing to produce a 58-foot missile. Nevertheless, the Navy remained uncomfortable with the operational limitations of the lengthy, liquid propellant-using Jupiter missile. One year later, the Navy withdrew from the program to pursue the development of the submarine-launched Polaris IRBM.

Yet another problem arose when, in 1956, the Secretary of Defense decided to limit the Army's operational responsibilities to those missiles having ranges of 200 miles or less, with the Air Force taking responsibility for those missiles with greater ranges. With this decision, the Army found itself developing a missile it could not use, while the Air Force was already well underway in developing its own IRBM, the Thor. By 1957 the Jupiter program was in a precarious position and thousands of pages of documentation were produced comparing the Thor and the Jupiter in anticipation of the termination of one of the two programs.

The successful launch of Sputnik I by the Soviet Union gave the Jupiter program a new lease on life. On 10 October 1957, President Eisenhower agreed with the Secretary's recommendation for the rapid development of both missiles. On 30 January 1958, President Eisenhower and the National Security Council approved a new IRBM plan that called for the deployment of four Jupiter IRBM squadrons, each composed of sixty missiles. In this plan, the first Jupiter squadron would attain operational status by 31 December 1958, and its sixty IRBMs would be operationally deployed by March 1960. The Air Force activated the first Jupiter IRBM unit, the 864th Strategic Missile Squadron, a component of SAC which was trained at Redstone Arsenal. The first operational-type Jupiter was launched in January 1959.



Jupiter Launch (KSC)

The United States sought permission from other countries to deploy the Jupiter missiles in potentially threatened and strategically advantageous locations. With the exception of the United Kingdom, negotiations with these countries progressed slowly. De Gaulle's decision in June 1958 to refuse the deployment of any Jupiter missiles represented a severe setback. This disappointment was tempered somewhat when the United States and Italy concluded an agreement (26 March 1959) for the deployment two Jupiter squadrons on Italian soil. Seven months later, on 28 October 1959, the United States and Turkey signed an agreement to deploy one Jupiter squadron on NATO's southern flank. The missiles in both Turkey and Italy were subsequently withdrawn as part of a secret agreement with the Soviet Union to withdraw their R-5 missiles from Cuba.

The Jupiter at the Cape

The Jupiter IRBM underwent significant testing at the Cape. On 14 March 1956 the first Jupiter

Jupiter preparing for suborbital flight with primates Able and Baker aboard, 28 May 1959 (NASA)

was launched from Complex 6. The launch at Complex 6 was one of 29 research and development launches that took place. In May 1958 a Jupiter missile was used to launch the first full-scale, heat-protected IRBM nose cone, demonstrating that reentry heating problems could be overcome. In January of 1959 the first operational Jupiter missile was launched and by 1960 the missile was deployed in Turkey and Italy.

During the mid- and late-1950s the research and tests were undertaken to develop the Jupiter C, a four-stage rocket derived from the Redstone missile and intended to place satellites in orbit. On its initial flight, 19 September 1956, the Jupiter C carried an inert, 84-pound payload to an altitude of more than 600 miles and a distance of 3,000 miles, setting new altitude and distance records. Less than one year later, a nose cone was recovered from a Jupiter C that had been launched several thousand miles down range. This marked the first such recovery of a reentry vehicle launched from such long ranges and President Dwight D. Eisenhower later proudly displayed this fire-blackened cone on national television.

The Jupiter C subsequently played a key role in many important missions of the United States space program. A modified Jupiter C served as the launch vehicle for Explorer I, the first artificial satellite placed in orbit by the United States. On 28 May 1959 another Jupiter C successfully completed a suborbital flight with primates Able and Baker aboard, marking the beginning of the United States' experiments with manned spaceflight.

Between March 1956 and January 1963 the Jupiter made a total of 65 launches from Launch Complexes 5, 6 and 26A and B.

LACROSSE

Program Milestones

Development:	1951
Production:	1955
First Successful Launch:	1953
Initial Operational Capability:	1959
Deactivation:	1964

Specifications

Historical Designation:	SSM-A-12
Service:	Army
Category:	Surface-to-Surface
Prime Contractor:	Cornell
Length:	19.2 feet
Weight:	2,300 pounds
Diameter:	20.4 inches
Wingspan:	9 feet
Propulsion:	Solid
Speed:	Mach 2
Guidance:	Radio Command
Range:	12-20 miles
Altitude:	15,000 feet
Warhead:	Nuclear or conventional

Lacrosse missile mounted on mobile launcher (WSMR)

The Lacrosse is a guided, surface-to-surface missile system intended for close tactical support of ground troops involved in frontline operations. The impetus for the development of the Lacrosse came from the experience of American soldiers in the Pacific during World War II. The heavily fortified islands held by the Japanese proved to be a major obstacle to the American advance in the Pacific. To defend these islands, the Japanese constructed networks of pillboxes, reinforced bunkers and other strongpoints, usually connected by a system of tunnels. On Iwo Jima, for example, in one area only 1,000 yards long by 200 yards wide, the Japanese had constructed around 800 such pillboxes. The attacking marines had to destroy them one by one. The casualty rates resulting from this type of fighting were very high. After this experience, the Marine Corps began to examine the possibilities for the development of a guided missile that would supplement conventional artillery and be powerful and accurate enough to destroy such fortified positions. As envisioned, the Lacrosse would be launched from a rear area in the general direction of a target designated by a Forward Observer (FO). At a specified moment, the FO would take control of the missile and direct it, by command guidance,

Lacrosse missile mounted on mobile launcher, 1956 (WSMR)

to the target. The missile derived its name from the similarities between this system of guidance and the game of lacrosse, in which one player passes the ball downfield to another player, who then slings the ball into the goal.

In 1947 the Navy Bureau of Ordnance issued contracts to the Applied Physics Laboratory of the Johns Hopkins University (APLJHU) and the Cornell Aeronautical Laboratory (CAL) to undertake feasibility studies for a missile system that would fulfill their requirements (Cornell was eventually chosen to be the prime contractor for the development of the weapon system). Two years later, in 1949, the Joint Chiefs of Staff established a new policy governing the development of guided missiles, assigning responsibility for the development of anti-aircraft guided missiles and for all ground-launched, short range, surface-to-surface guided missiles intended to support conventional artillery to Army Ordnance. As a result, in August 1950, Army Ordnance became responsible for the Lacrosse program.

The Lacrosse was originally classified as a "close support artillery guided missile system" intended for the reduction of enemy hardpoint targets. This demanded that the system possess a high degree of accuracy. The initial suggested requirements called for a Circular Probable Error (CPE) of five yards. The desired maximum range for the missile was to be at least 20,000 yards. The missile would carry a 100-lb warhead with research priority given to a shaped charge explosive warhead. To increase the mobility of the forward guidance team, their equipment was to weigh no more than 150 lbs.

These requirements changed over time. In March 1956 the Department of the Army reprioritized the warhead development programs for Lacrosse. Of the three types of warheads then under consideration for the Lacrosse, atomic warheads were given the highest priority, followed by controlled fragmentation warheads and shaped charge warheads. This reprioritization of warhead development reflected a pending change in the tactical mission and classification of Lacrosse. In June 1957, the Department of the Army issued revised military characteristics for the missile system in which Lacrosse was now classified as a "general support field artillery guided missile system." The tactical mission of Lacrosse was expanded and now it was to be employed as "corps artillery in general support and reinforcing roles against appropriate personnel and materiel targets, including heavy fortifications." To ensure maximum mobility, it was to have the capability of being transported by helicopter. The FO would now work in conjunction with division artillery in support of airborne, infantry and armor units. The maximum desired range was increased to 35,000 yards. The accuracy specifications called for a CPE of 2-40 meters, depending on the guidance range involved.

Several problems and vulnerabilities existed in the Lacrosse system. The most important and vexing difficulty concerned the vulnerability of the guidance system to enemy countermeasures. Early in 1956 a new electronic counter-countermeasure (ECCM) system, designated the

Lacrosse launch, 1956 (WSMR)

MOD I, was designed to reduce Lacrosse's vulnerability. Unfortunately, the Mod I research effort was terminated three years later as a result of funding shortages. With the cancellation of the MOD I program, the Lacrosse system remained extremely vulnerable. As one Marine Corps Brigadier General told the Subcommittee on Department of Defense Appropriations:

> "It takes a very simple device to interfere with the control of the Lacrosse… If you put a nuclear warhead on one of these things, it is going to be a little bit unfortunate if somebody guided it to the wrong place, or if it got to the wrong place without any guidance. It is a $70,000 missile and it can be interfered with by [a] local [radio] station."

In July 1959 the US Marine Corps announced its immediate withdrawal from the program.

Testing continued, however, for both the missile and the supporting ground equipment. On 1 July 1959 tactical equipment for the activation of the first Lacrosse battalion was delivered to Fort Sill, Oklahoma. In December the first Lacrosse battalion was deployed (5th Bn, 41st Artillery) in the United States. In March 1960 a Lacrosse battalion was deployed in Europe and one month later another battalion was posted to Korea. Six other battalions were subsequently deployed throughout 1960. When deployed, the Lacrosse system, while basically acceptable, was far from being fully reliable and perfected. Problems continued to plague the system and, in January 1961 the Army initiated a program that would gradually reduce the inventory and strength of the deployed battalions. In February 1964 the Lacrosse system was classified as obsolete.

LITTLE JOHN

Program Milestones

Development:	1956
Production:	1958
Initial Operational Capability:	1960
Deactivation:	1969

Specifications

Historical Designation:	XM-51
Service:	Army
Category:	Surface-to-Surface
Prime Contractor:	Douglas/Redstone
Length:	14.5 feet
Weight:	780 pounds
Diameter:	12.5 inches
Wingspan:	3 feet
Propulsion:	Solid
Speed:	Mach 2.3
Guidance:	Unguided
Range:	10 miles
Altitude:	N/A
Warhead:	Nuclear or conventional

Little John Rocket (Redstone)

The Little John rocket was the 'kid brother' to the Honest John artillery rocket. Like its predecessor, the Little John was a free-flight, unguided artillery rocket designed to deliver the heavy explosive power of heavy artillery and possessed a range comparable to that of tube artillery. The system was designed primarily for use in airborne assault operations and used a lightweight launcher that made the system very mobile.

In 1953, the Assistant Chief of Ordnance developed plans for a family of atomic rocket weapons based on the Honest John system and having overlapping range capabilities. This family of missiles was to include the middle-range Honest John, the long-range Honest John Senior, and the short-range Honest John Junior. Douglas Aircraft Corporation was given responsibility for the Honest John Junior research program. Over the course of the next several years the design requirements changed considerably and in December 1954, the Office of the Chief of Ordnance (OCO) set up the project framework for the development of a weapon system that would become known as the Little John, replacing the Honest John Junior. On 14 June 1955 the Little

Little John and launcher, 1959 (Redstone)

John program was formally established. As a result of contracting problems with Douglas Corporation, Redstone Arsenal assumed primary responsibility for the Little John program.

In 1956 the Little John program was placed on a 'crash' basis to develop, with the smallest possible delay, an atomic delivery vehicle for use in airborne operations. Problems with accuracy delayed the field deployment of the Little John missile but finally, in 1961, the 1st Missile Battalion, 57th Field Artillery, based in Okinawa, received the first Little John rockets. In total, seven Little John units were activated in 1961. In 1966 two Little John units were deployed in the South Pacific.

The Little John was a relatively short-lived weapon system. By November 1966, only four Little John units remained active. Two of these were deployed within the continental United States and the two others were deployed in the South Pacific. In August 1969, the Little John rocket was classified as obsolete.

MACE

Associated Launch Complex

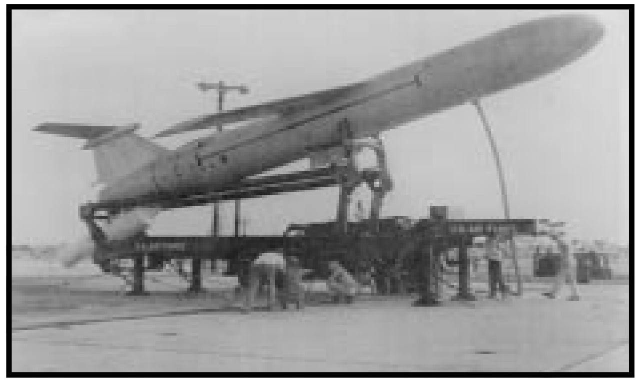
Launch Complexes 21, 22

Program Milestones

Development:	1954
Production:	1958
First Successful Launch:	1956
Deactivation:	1966

Specifications

Historical Designation:	TM-61B, TM-76
Service:	Air Force
Category:	Cruise
Prime Contractor:	Martin
Length:	46.8 feet
Weight:	18,750 pounds
Diameter:	54 inches
Wingspan:	28.6 feet
Propulsion:	Booster, turbojet
Speed:	Mach .8
Guidance:	Inertial
Range:	500 miles
Warhead:	Nuclear or conventional



The Mace missile (KSC)

The Mace was an improved version of the Matador missile. Like its predecessor, the Mace was a surface-launched tactical missile designed to destroy ground targets. The Mace could be launched from a mobile trailer or from a bomb-proof shelter with the aid of a solid-fuel rocket booster. After launch, this booster dropped away and a jet engine then powered the missile to the target.

The main improvement over the Matador was the Mace's guidance system. In March 1948 the Goodyear Aircraft Corporation began laboratory tests of the new ATRAN (Automatic Terrain Recognition And Navigation) guidance system. ATRAN was a radar map-matching system in which the return from a radar scanning antenna was matched with a series of "maps" carried on board the missile which corrected the flight path if it deviated from the film map. Flight tests began in October 1948. Initially, the Martin Company showed little initial interest in the new system, but problems with the Matador's guidance necessitated a change. In August 1952, Air Materiel Command initiated the mating of the Goodyear ATRAN with the Martin Matador. This mating resulted in a production contract in June 1954. ATRAN could not be easily jammed and was not range-limited by line-of sight, but its range was restricted by the availability of radar maps and missile range. Although in time it became possible to construct radar maps from topographical maps, ATRAN initially performed poorly.

USAF installed ATRAN in the TM-61B variant of the Matador missile, and nicknamed it the Mace missile. The Mace differed significantly from the TM-61A and TM-61C models. Mace had a longer fuselage, shorter wings, and more weight than the previous models and, with its 5,200-pound-thrust J33-A-41 turbojet engine and a 97,000-pound-thrust booster, was also more powerful. It first flew in 1956 and could reach Mach .7 to .85 over a 540-mile range at low level (as low as 750 feet), and 1,285 miles at high altitude. Because of these substantial differences of configuration and capability, the Air Force redesignated Mace as the TM-76A. These improvements came at a price: the new TM-76A cost about $250,000, compared to $60,000 for the TM-61C. One benefit, however, was that the Mace was designed to use the same ground support equipment and transport as the Matador.

Improvements continued and the USAF installed a jam-proof inertial guidance system aboard the Mace “B” (designated TM-76B) which had a range exceeding 1,300 miles. To enhance mobility, Martin designed the Mace’s wings to fold for transport. This is in contrast to the Matador’s wings, which were transported separately from the missile and then bolted on for flight.

In 1959, USAF deployed the Mace in Europe where it served alongside the Matador before the latter was phased out in 1962. Six Mace missile squadrons (comprising the 38th Tactical Missile Wing) served in Europe with just under 200 TM-61s and TM-76s. In Korea, the 58th Tactical Missile Group became combat ready with 60 TM-61Cs in January 1959. It ceased operations in March 1962, only a few months after the 498th Tactical Missile Group in December 1961 took up positions in semi-hardened sites on Okinawa.


Mace Launch, Cape Canaveral (KSC)

The Mace at the Cape

On 30 June 1959 construction began on a Mace launch complex. Construction was completed on 12 February 1960. This prototype tactical launch site was built on the site of the old Pad 21, previously used by the Bull Goose program.

The first Mace launch at the Cape was that of a Mace B (TM-76B) on 29 October 1959. This test was considered a success and met all of its objectives, while a second launch, on 4 December, tested the inertial guidance system and the missile’s ground support equipment. In February and March of 1960, two more Mace Bs were launched from Complex 21, with three more launches taking place before the end of June. Mace B launches continued at Cape Canaveral through 17 June 1963.

MATADOR

Associated Launch Complex

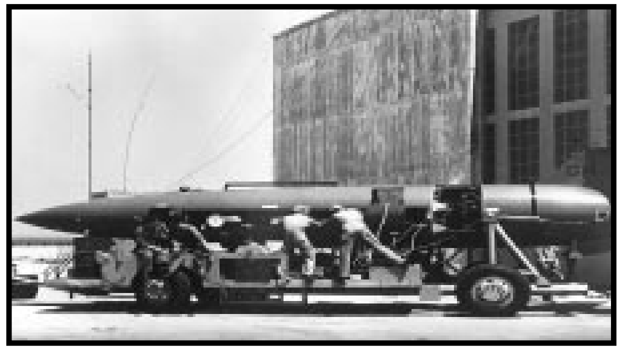
Launch Complexes 1-3, 22

Program Milestones

Development:	1946
First Successful Launch:	1949
Initial Operational Capability:	1954
Deactivation:	1969

Specifications

Historical Designation:	TM-61A
Service:	Air Force
Category:	Surface to Surface
Prime Contractor:	Martin
Length:	39.7 feet
Weight:	11,550 feet
Diameter:	9 feet
Wingspan:	28.6 feet
Propulsion:	Solid booster, turbojet
Speed:	650 mph
Guidance:	Command
Range:	600+ miles
Altitude:	44,000 feet
Warhead:	Nuclear or conventional



Preparations for Matador Launch, 1951 (KSC)

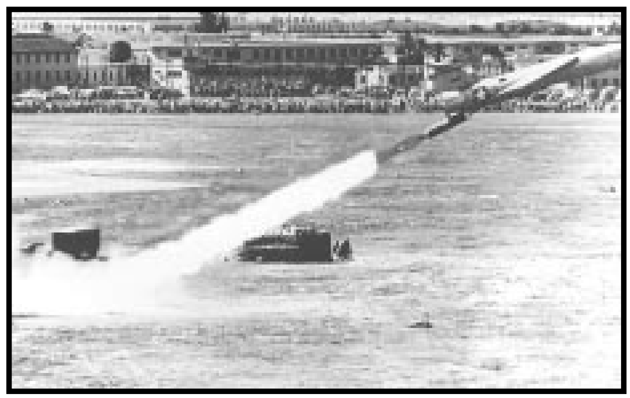
In August 1945, the Army Air Forces (AAF) established a requirement for a 175- to 500-mile range surface-to-surface missile capable of flying at 600 miles per hour. In 1946, the Martin Company received a one-year contract to study both a subsonic and a supersonic version of such a missile. The AAF canceled the program for the supersonic version. Just a few months later, the program for the subsonic version was itself threatened with cancellation until the outbreak of the Korean War prompted the Air Force to give the missile top priority (September 1950).

In size and appearance the Matador missile, as this subsonic missile came to be called, resembled a contemporary jet fighter. The first test flight of the new missile took place at Holloman Air Force Base, New Mexico, on 19 January 1949. Testing continued at Holloman and at the United States Air Force Missile and Test Center at Cape Canaveral, using both prototype and production models, until 1954.

The guidance system of the Matador presented a particular problem, as the guidance radar's range proved less than the missile's flying range. The type of guidance used in the Matador required a ground-based operator to track and guide the missile, which, requiring line-of-sight communications, limited the guided range to 250 miles. In late 1954, USAF provided the Matador with a new guidance system, known as Shanicle (for Short Range Navigation Vehicle). With this system the new Matador, redesignated the TM-61C, automatically flew a hyperbolic grid and obtained an overall reliability of 71 percent and a CEP of 2,700 feet. But while using the Shanicle guidance system, the Matador remained limited to a range appropriate for line-of-sight transmissions. In addition, the missile remained vulnerable to electronic countermeasures. These problems were rectified when the Goodyear Aircraft Corporation developed an Automatic Terrain Recognition and Navigation (ATRAN) guidance system. The ATRAN system matched the characteristics of the terrain over which the missile flew with information contained in a stored map. This system could not be easily jammed and the range of the missile would not be limited by line-of-sight considerations. This guidance system was used on the TM-61B model, a much-improved Matador that would later be rechristened the Mace TM-76A.

In October 1951, the Air Force activated the 1st Pilotless Bomber Squadron at the United States Air Force Missile Test Center (AFMTC) at Cape Canaveral. There it received training at the hands of the 6555th Guided Missile Squadron. In March 1954, the 1st Pilotless Bomber Squadron deployed to Germany with TM-61As (Matadors) and became operational the following year. The second unit to be activated was the 69th Pilotless Bomber Squadron. It also received training from the 6555th Guided Missile Squadron and left for Germany in September of 1954. Six missile squadrons, comprising the 38th Tactical Missile Wing armed with Matador TM-61s and subsequently Mace TM-76s, would eventually serve in Europe. Units also served in Okinawa and Korea. Problems continued to plague the Matador, however, and in 1959 the phase out of the Matador began. It was an exceedingly slow process, however, and the last unit, the 71st Tactical Missile Squadron, was not phased out until April 1969.

Matador Launch (Brookings)



Matador Launch for the public at Patrick AFB on Armed Forces Day (20 May 1956) (Cleary)

Matador Testing at the Cape

The Martin Company brought the Matador to the Cape in the spring of 1951. The first Matador launch from the Cape took place not long after, on 20 June 1951. This was the first Air Force missile to become operational subsequent to flight testing at the Cape. In the twelve months that followed, seventeen experimental Matador missiles were launched from the Cape. These tests provided valuable information concerning the viability of the Matador's launcher, airframe and guidance systems. Testing continued in the following years, with 23 Matadors launched in the last six months of 1953 alone. In 1956, more than thirty Matadors were launched from the Cape for both training and research and development purposes. On 20 May, Armed Forces Day, a Matador was launched from Patrick Air Force Base in the first public demonstration of the weapon system. The R & D launches were completed in 1956, but training launches continued at the Cape well into 1961. A total of 286 Matador missiles were launched from Complexes 1-3 between 1951 and 1962.

MINUTEMAN

Associated Launch Complex

Launch Complexes 31, 32

Program Milestones

Development:	1958
Production:	1962
First Successful Launch:	1961
Initial Operational Capability:	1962

Specifications (Minuteman IA)

Historical Designation:	SM-80, LGM-30
Service:	Air Force
Category:	ICBM
Prime Contractor:	Boeing
Length:	53.8 feet
Weight:	65,000 pounds
Diameter:	6 feet, 2 inches
Propulsion:	Solid
Speed:	Mach 19.7
Guidance:	All-inertial
Range:	6,300 miles
Altitude:	700 miles
Warhead:	Nuclear

Minuteman launch (KSC)

The solid-fueled Minuteman ICBM has formed the backbone of the Air Force's land-based ballistic missile arsenal since the early 1960s. Standing alert in hardened, dispersed, underground silos, these missiles are capable of being launched almost instantaneously. By ensuring a swift and devastating response to aggressive attacks on the United States or its allies, Minuteman ICBMs have been a major factor in preventing a deadly nuclear confrontation during the Cold War. The Air Force's Strategic Air Command (SAC) was the agency responsible for the deployment and maintenance of the United States' Minuteman force during the Cold War.

The Minuteman weapon system was a revolutionary concept that represented a significant advance over the Air Force's first generation Atlas and Titan ICBMs. Until the development of super accurate guidance systems by the Soviet Union in the late 1970s, the Minuteman weapon system was nearly invulnerable. The origins of the Minuteman missile can be traced back to the mid-1950s when the United States and the Soviet Union were both racing to develop and deploy ballistic missile weapon systems. Even as the Air Force was accelerating the development of its liquid-fueled Atlas and Titan ICBMs, military leaders were already looking to develop a more effective, flexible, and less-expensive missile weapon system. A solid-fueled missile was an attractive option because it would allow for a much quicker response time than a liquid-fueled missile. Also, because solid fuels are much less volatile and corrosive than liquid fuels, a solid-fueled missile could safely maintain alert status for long periods of time without extensive maintenance.

The Air Force first became interested in a solid-fueled ICBM in 1954 but at that time solid-fueled motors did not produce sufficient thrust and were difficult to control. Nonetheless, the Air Force began sponsoring research in solid fuels at the Wright-Patterson Air Development Center, Ohio, in late 1955. By late 1957, the research had progressed to the point where development of a viable solid-fueled ICBM was possible. Consequently, Colonel Edward Hall of the Air Force's Ballistic Missile Division (AFBMD) designed a small, relatively inexpensive, three-stage, solid-fueled missile. Originally known as Weapon System Q, this missile became officially designated as Minuteman in September 1957. Colonel Hall's idea was to base Minuteman ICBMs in unmanned, hardened, and dispersed silos that were linked electronically to a series of launch control facilities.

The initial Air Force response to Hall's basing concept was unenthusiastic. This quickly changed however, when the Department of the Navy began promoting its solid-fuel submarine-launched Polaris ballistic missile. Anxious not to lose its dominant role in the development and operational control of ballistic missiles, the Air Force began pressing for an accelerated Minuteman program. The Minuteman program became a major Air Force objective in early 1958 although it did not receive top national priority status until March 1961.

The prime contractors for the Minuteman were the Boeing Airplane Company (airframe), the Thiokol Chemical Corporation (stage 1 propulsion), the Aerojet-General Corporation (stage 2 propulsion), the Hercules Powder Company (stage 3 propulsion), and the Autonetics Division of North American Aviation (guidance system). The AVCO Corporation won the contract to build the Minuteman's thermonuclear warhead.

The Minuteman development program proceeded rapidly. The Air Force successfully tested the first full-scale model Minuteman missile from a silo launcher at Edwards Air Force Base (AFB), California on 15 September 1959. The Air Force conducted seven additional tests at Edwards AFB before switching activities to Cape Canaveral and the Eastern Test Range. After the first two Minuteman launch attempts at Cape Canaveral were aborted, the Air Force conducted its first "all up" test of a Minuteman missile in February 1961. Utilizing a surface pad, this test included all three stages of the missile and its operational subsystem. Officials watched as the missile flawlessly completed its programmed 4,600-mile flight down the Eastern Range. After three similar test flights, the Air Force began a series of test launches from a prototype underground silo at Cape Canaveral. The Minuteman program entered a new phase in 1962 when the operational testing and development program began at Vandenberg AFB, California.

Even as the Minuteman program raced forward, the Air Force began developing improved versions of the missile. The original missile, eventually dubbed Minuteman I, was developed in two versions. Minuteman I, or Minuteman A, was the first missile. A flawed first stage of this missile substantially reduced its range and prompted the production of the Modified Minuteman I, or Minuteman B. This version incorporated several performance improvements and had a range of approximately 6,300 miles. In 1962, the Air Force awarded the Boeing Company a contract to develop the Minuteman II. Also designated Minuteman F, the Minuteman II had a larger second-stage engine, an improved guidance system, greater range (approximately 7,000 miles) and payload capabilities, more flexible targeting, and an increased capability of surviving an attack.

The Air Force organized its Minuteman force into six wings. These wings were located at existing SAC installations to take advantage of already existing government facilities. Each Minuteman wing was composed of three or four fifty-missile squadrons with each squadron being further divided into five flights of ten missiles. A Minuteman flight consisted of a launch control center (LCC) and ten unmanned launch facilities (LFs). Each LF was located a minimum of three miles from its LCC and from other LFs. This dispersal ensured that a single enemy warhead could not destroy multiple missile sites.

The facilities for the first Minuteman squadron were at Malmstrom AFB, Montana, and were completed in September 1961. The first flight of Minuteman ICBMs became operational at Malmstrom in October 1962. By the following July, the first complete Minuteman wing (Wing I) was operational at Malmstrom. Four additional Minuteman wings were operational at SAC installations by June 1965. Located at Ellsworth AFB in South Dakota (Wing II), Minot AFB in North Dakota (Wing III), Whiteman AFB in Missouri (Wing IV), and F.E. Warren AFB in Wyoming (Wing V), these Minuteman wings brought the total number of Minuteman I ICBMs deployed to 800.

Minuteman I launch, Cape Canaveral (KSC)

While the last Minuteman I ICBMs were being installed in their silos, the Air Force was readying its final wing (Wing VI) at Grand Forks AFB in North Dakota to accept Minuteman II missiles. The first Minuteman II squadron went on operational alert at that installation in April 1966. A second Minuteman II squadron went on operational alert at Malmstrom AFB in May 1967 bringing the total number of Minuteman II ICBMs deployed to 200. The total Minuteman force at that point stood at 1000. In an effort to further the effectiveness of its force, the Air Force began replacing Minuteman Is with Minuteman IIs under its Force Modernization Program. By the end of the decade, the Minuteman force consisted of 500 Minuteman I and 500 Minuteman II ICBMs.

Development of the Minuteman III began in December 1964. This missile had several advantages over its predecessors, including an improved third stage engine, increased range (over 8,000 miles) and payload capacity, an advanced reentry system, an improved guidance system, and the ability to carry up to three independently-targetable warheads, a technology known as MIRV (for multiple independently targetable reentry vehicle). The Air Force conducted the first successful Minuteman III test flight at Cape Canaveral in August 1968. After the basic design parameters of the Minuteman III were established, the Air Force began the operational development and testing phase of the program at Vandenberg AFB. The first Minuteman III launch at Vandenberg took place in April 1969.

Minot AFB received the first flight of Minuteman III ICBMs in June 1970. The Air Force completed the deployment of this initial wing by December of the following year. In addition to Minot AFB, Grand Forks AFB, F.E. Warren AFB, and Malmstrom AFB also received Minuteman III squadrons. The Air Force placed these Minuteman III ICBMs in modified Minuteman I silos and Minuteman II silos. In the process the Air Force retired its entire Minuteman I force and 50 of its Minuteman II missiles. When the last 50 Minuteman IIIs became operational at Malmstrom AFB in July 1975, the Force Modernization Program came to an end. At that point, the SAC Minuteman force stood at 450 Minuteman IIs and 550 Minuteman IIIs. These missiles (along with 54 Titan II ICBMs), SAC's fleet of manned nuclear bombers, and the Navy's missile launching submarines, formed the triad of the United States' strategic nuclear force. This force stood on alert twenty-four hours a day to deter any country from launching a hostile nuclear attack on the United States or its allies.

The nation's Minuteman force stood at 1000 until 1986 when the Air Force deployed fifty MX Peacekeeper ICBMs in modified Minuteman III silos at F.E. Warren AFB under its Strategic Modernization Program. This action reduced SAC's Minuteman force to 950 (450 Minuteman IIs, 500 Minuteman IIIs). It stayed at this level for the next five years. In 1991, President George Bush and Soviet President Mikhail Gorbachev signed the Strategic Arms Reduction Treaty (START). START called for each country to

Minuteman I launch from Pad 31, 1 February 1961 (Cleary)

reduce its nuclear arsenal by approximately 30 percent over a span of seven years. In compliance with START, President Bush ordered the Air Force to begin removing all 450 of its Minuteman II ICBMs from operational alert. Over the next three years, Air Force crews removed the Minuteman II ICBMs from their silos, filled in the silos with rubble, and covered the launch control centers with rubble and concrete.

The Minuteman at the Cape

The Minuteman was the last ICBM to be tested at Cape Canaveral. The first Minuteman I launch occurred from Pad 31 on 1 February 1961. This flight was very successful and was the first launch operation in which all stages of a multi-staged missile were tested on the initial flight of a research and development program. Two other launches subsequently took place at Pad 31. The Minuteman I test program continued through 1964. During the last half of 1964 the facilities were modified to accommodate Minuteman II testing. The first Minuteman II test launch was conducted from the newly constructed Silo 32 on 24 September. A total of ten Minuteman II missiles were launched from the Cape, the last on 6 February 1968. The first Minuteman III launch was conducted from Silo 32 on 16 August 1968. Testing of the Minuteman III continued through 1970.

NAVAHO

Associated Launch Complex

Launch Complexes 9, 10

Program Milestones

Development:	1946
Production:	1954
First Successful Launch:	1957

Specifications

Historical Designation:	XMS-64
Service:	Air Force
Category:	Surface-to-Surface
Prime Contractor:	North American Aviation
Length:	87.3 feet
Weight:	120,500 pounds
Diameter:	6.5 feet
Wingspan:	40.2 feet
Propulsion:	2 ramjets
Speed:	Mach 3.25
Guidance:	Inertial
Range:	5,500 miles
Altitude:	71,000 feet
Warhead:	Nuclear

The Navaho missile (NASA)

The North American Navaho missile was developed concurrently with the Northrop Snark missile. The USAF intended to get the subsonic Snark operational first, to be followed by the supersonic Navaho. As missile technology progressed, it was expected that the two air-breathing missiles would later be replaced by ballistic missiles. The goal of the Navaho program was to produce a surface-to-surface guided missile capable of carrying an atomic warhead 5,500 nautical miles at a speed of at least Mach 2.75 with sufficient accuracy to ensure that at least 50 percent of all missiles struck within 1,500 feet of the target.

The origins of the program lay in the months before the end of World War II when North American Aviation assigned five engineers to

Navaho missile in flight (NASA)

begin studying missile technology. Using captured documents and equipment relative to the German V-2 missile program, this research group, known as the Technology Research Laboratory (TRL), focused on research into high-thrust engines, inertial guidance and high speed aerodynamics. In December 1945, TRL submitted a proposal to the Air Force to continue their missile research, proposing a three-part effort comprised of a study of a winged V-2 concept, a study of the feasibility of replacing the rocket engine of the V-2 with a supersonic ramjet, and an attempt to develop a rocket booster to provide intercontinental capability.

In April 1946, the Air Force agreed to the first part of this scheme under project MX-770. This project called for the development of a 175- to 500-mile range surface-to-surface missile. Project requirements changed continuously over the course of the next several years. In July 1947, the Air Force added the 1,500-mile range, supersonic ramjet to the program. By March 1948, the program called for a 1,000-mile test vehicle, a 3,000-mile test vehicle, and a 5,000-mile operational missile. In 1950, the Air Force considered launching a Navaho from a B-36, but dropped the idea the following year. Final guidelines were not established until September 1950. These guidelines called first for the design, construction, and test of a turbojet test vehicle, followed by an interim missile with a 3,600-mile range, and culminating in an operational weapon with a 5,500-mile range.

Several test vehicles were developed during this project, including the X-10, the GS-26, and the final version, the GS-38, also known as the XSM-64. The X-10 series was produced to test the missile's canard aerodynamics, flight control system, and inertial guidance. The X-10 was a recoverable missile. It carried retractable landing gear and was launched like a conventional aircraft. Upon completing their test flights, the vehicles simply flew back for a landing. The XSM-64 was the production version of the Navaho missile. It was comparable to an actual bomber, and could fly at a speed of 2,150 mph at a maximum altitude of 60,000 feet. It was launched at a 90-degree angle attached to a cylindrical booster. Three engines at the base of the booster were fed by liquid oxygen/RP-1 (kerosene) liquid fuel. These engines produced a combined 450,000-pound thrust at launch. Designed to be reused following nonlethal flights, Navaho XSM-64 vehicles also carried retractable landing gear and were able to return for a landing.

Navaho in vertical position, Cape Canaveral, 1957 (Cleary)

The Navaho program was plagued by continuous problems and launch failures. There were serious problems with nearly all of the missile systems and as a result, production and operational schedules slipped badly. In 1954 and 1955, USAF considered pushing the Navaho into operational service, but problems and delays blocked that idea. In late 1955, the Air Force accelerated the Navaho program, giving it a priority second only to that of the intercontinental ballistic missiles (ICBMs) and intermediate range ballistic missiles (IRBMs). The Air Force hoped to have the Navaho operational by October 1960. Continuing problems and failed flight tests, however, continued to plague the program and earned the SSM-64 the nickname "Never go, Navaho." The first XSM-64 launch in November 1956 at the Cape, ended in failure after a mere 26 seconds of flight. Ten unsuccessful launch attempts occurred before a second Navaho got airborne on 22 March 1957, and remained aloft for four minutes and 39 seconds. An attempt of 25 April ended in an explosion just seconds after lift-off, while a fourth flight on 26 June 1957 lasted only four minutes and 29 seconds.

This lack of positive results, combined with cost pressures, slippages in schedules, and increasing competition from cheaper, easier to produce ballistic missiles, resulted in the cancellation of the Navaho program a few weeks later in early July 1957. Despite the frustrations of the Navaho program, the USAF saw the Navaho as a leap forward in the state of the art of missile technology. Research done during the Navaho program greatly facilitated later missile programs and Navaho technology, including booster engines, cryogenic propellant, inertial guidance systems and other equipment, was successfully adapted for use in other missile programs. The pump-fed Navaho booster engine technology, itself adapted from the German V-2 missile, was used in the Atlas, Redstone, Jupiter and Thor programs. The Hound Dog air-launched cruise missile was a direct descendant of the Navaho program, with an airframe, guidance and autopilot systems similar to those used in the Navaho test vehicles. The Navy's nuclear submarine Nautilus, the Polaris submarines, and the Navy's A-5 Vigilante bomber adapted the Navaho's inertial autonavigation system. The engines for the Redstone, Jupiter, Thor and Atlas missiles all benefited from the experience gained in the Navaho research program. While the Navaho proved impractical and costly as a missile, the research program did have positive benefits.

Navaho X-10, 24 September 1958 (Cleary)

The Navaho at the Cape

North American Aviation opened its field office at Patrick Air Force Base, Florida, in the Spring of 1953. Operations were scheduled to begin in July of 1953 but construction delays made this impossible. The Air Force did not issue construction contracts for the two missile assembly buildings and supporting utilities until mid-1953. Construction of the first G-26 launch site, Vertical Launch Facility No. 1 (Complex 9) began in September.

The first launch at the Cape was that of an X-10 on 19 August 1955. Support facilities were completed in the last half of 1955, and seven more X-10s were launched from the Cape over the next twelve months. The first launch of an XSM-64 took place on 6 November 1956; launches continued through 1957. From the beginning, the XSM-64 testing at the Cape was plagued by problems and failures. As noted above, there were four Navaho launch failures between November 1956 and 27 June 1957. In addition to these failures, a series of 1,500-mile auto-navigator test flights were attempted in the first three months of 1957 without a single successful launch. On 13 July 1957 the Air Force canceled the Navaho program.

NIKE AJAX

Associated Launch Complexes

N/A

Program Milestones

Development:	1950
Production:	1951
First Successful Flight:	1952
Initial Operational Capability:	1953

Specifications

Historical Designation:	SAM-A-7
Service:	US Army
Category:	Surface to Air
Prime Contractor:	Bell
Length:	21 feet*
Weight:	1,000 pounds*
Diameter:	12 inches
Wingspan:	4 feet, 6 inches
Propulsion:	Solid propellant
Speed:	Mach 2.3 (1,679 mph)
Guidance:	Command
Range:	25 to 20 miles
Altitude:	Up to 70,000 feet
Warhead:	High Explosive

* without booster

Nike Ajax (KSC)

In 1944, faced with German advances in rocketry, jet aircraft, and high-flying bombers, military planners realized that traditional anti-aircraft weaponry could no longer fulfill its mission. In 1945, the Army Chief of Ordnance issued a contract to Western Electric and Bell Telephone Laboratories (BTL) to determine the feasibility of a new high-powered, anti-aircraft rocket torpedo. In mid-1945, Western Electric/BTL reported that such an anti-aircraft missile system was indeed feasible and presented the parameters of a proposed system that came remarkably close to the system actually fielded eight years later. It was decided to use already existing devices and have the majority of the components ground-based, leaving the vehicle as simple and reliable as possible. The initial design called for eight booster rockets to be wrapped around the tail of the missile. The development schedule projected a weapon system ready for production in 1949. This schedule was not met.

The first static firing of a Nike missile, named after the Greek goddess of victory, occurred at White Sands Proving Ground, New Mexico, on 17

September 1946. A week after the first static test, the first actual launch of a missile occurred at White Sands. Testing continued throughout 1947 and 1948. By 1948, however, the project had fallen behind schedule. Problems with the reliability of the cluster booster configuration forced designers to adopt a different booster, one that had been originally developed for the Navy's "Bumblebee" anti-aircraft missile. A continuing combination of technical and funding problems created further delays in the program. In 1950, however, in response to the tense international situation, the Nike program was accelerated and work began on moving beyond the research and development and into the production of a tactical system.

In October 1951, the United States' first guided anti-aircraft missile, Nike-One, was fired on the White Sands range. This marked the birth of the extended family of Nike missiles. By July 1952, the first production-line Nike was launched. Testing continued to evaluate the missile and improve the reliability of the production models. The first complete tactical system was tested 25 February 1952 while the R&D program was still in progress. Although the missile was little changed in configurations from the original specifications, the booster had undergone radical changes resulting in a simpler, more reliable and easier to handle unit. Three Nike I ground systems (including radars and related equipment) and 1,000 missiles were delivered to White Sands in 1952. Production models were scheduled for 1953.

The Nike Ajax system was designed to supplement and then replace gun batteries deployed around the nation's major urban areas and vital military installations. The original basing strategy of the Army Anti-Aircraft Command (ARAACOM) projected a central missile assembly point from which missiles would be taken out to prepared above-ground launch racks ringing the defended area. However, ARAACOM

Nike Ajax at White Sands Missile Range, 1956 (WSMR)

discarded this semi-mobile concept because the system needed to be ready for instantaneous action to fend off a "surprise attack." Instead, a fixed-site scheme was devised.

Due to geographical factors, the placement of Nike Ajax batteries differed at each location. In Chicago, for example, the broad expanse of Lake Michigan forced ARAACOM to erect batteries along the lakefront near the heart of the city. In planning Chicago and other area defenses, ARAACOM planners carefully examined all possible enemy aircraft approaches to ensure no gaps were left open. Initially, the planners chose fixed sites well away from the defended area and the Corps of Engineers Real Estate Offices began seeking tracts of land in rural areas. However, in late 1952, the planners determined that close-in perimeter sites would provide enhanced firepower. Staggering sites between distant and close-in locations gave defenders a greater defense-in-depth capability. The Corps Real Estate Offices recognized that projected acreage requirements of 119 acres per site would not be feasible in some of the urban areas selected for missile deployment. To solve this problem, design architect Leon

Nike Ajax ready for launch (KSC)

Chatelain, Jr., devised an underground magazine configuration that cut the land requirement down to 40 acres. Capable of hosting 12 Nike Ajax missiles, each magazine had an elevator that lifted the missile to the surface in a horizontal position. The Army constructed a prototype magazine at White Sands in June 1953 and fired missiles from the magazine elevator platform to demonstrate the design's practicality. With the design proven, Chatelain, along with the architectural firm of Spector and Montgomery, began preparing drawings for nationwide distribution. On 28 October 1953, ARAACOM directed that the underground magazine design would be used in most cases.

The first Nike Ajax unit deployed to an above-ground site at Fort Meade, Maryland, in March 1954, and on 30 May 1954, became fully operational on an around-the-clock combat ready status. Between 1951 and 1958, 13,714 Nike Ajax missiles were produced. Before 30 June 1958, 222 Nike Ajax systems had been deployed in the continental United States and 24 systems in the European theater. The Ajax batteries were typically configured in a defensive ring around the nation's cities and vital industrial and military installations.

One of the major challenges facing the Army in deploying dozens of Nike battalions in just a few years was training the thousands of soldiers needed to man these systems. The Nike Package Training Program at Fort Bliss met this challenge. The First Guided Missile Group, better known as the Nike Group, had as its subordinates the First and Second Training Battalions. Their responsibilities included training "packages" of 14 officers and 123 enlisted men to be the nucleus of each Nike battalion. Prior to this five weeks of package training, individual groupings had specialized training of differing degrees. Eighty-nine members of the package would graduate from the eight-week Specialist Training Program, which prepared them for the routine operation of the NIKE system from emplacement, energizing and alignment to missile loading and target tracking.

The remaining 34 enlisted men of the package and the 14 officers were trained in the maintenance and repair of the Nike system. Two of the officers graduated from a 31-week course at the Artillery School, the highly technical 1181 Course, and were awarded the title of guided missile systems officer. Another essential course was the 1177 Course that trained guided missile maintenance officers. The remaining 12 officers attended a 15-week course.

Once these groups came together, they spent five weeks on integrated system training as a team. They were issued two sets of battery control equipment, one of which they took 165 miles north of Fort Bliss to Red Canyon Range, NM, to culminate their training by firing a live missile. After this final phase of their training was complete, they returned to Fort Bliss and usually moved their equipment via the railroad to its final destination to protect one of the nation's vital areas.

The Army National Guard units played a key role in manning the new anti-aircraft systems. In 1957, the Department of the Army authorized the Army National Guard to convert 32 anti-aircraft battalions, then equipped with conventional guns, to Nike Ajax missile battalions. The 4th Missile Battalion Nike Ajax, 251st Artillery, California Army National Guard, was the first National Guard surface-to-air guided missile battalion integrated into the active continental United States defense mission. This unit assumed around-the-clock operations at four battery sites in the Los Angeles area on 14 September 1958. At the completion of the phased training program, the Army National Guard was furnishing 76 batteries in 14 states, defending 15 areas. These were the first US Reserve forces with modern surface-to-air missiles. In May 1962, the first of the Army National Guard Nike Ajax units were phased out and started retraining to operate and maintain the second-generation Nike Hercules. The last four Nike Ajax sites manned by the National Guard were phased out in May 1964 at Norfolk, Virginia.

NIKE HERCULES

Program Milestones

Development:	1953
Production:	1955
First Successful Launch:	1954
Initial Operational Capability:	1958
Deactivation:	1979

Specifications

Historical Designation:	SAM-N-25
Service:	Army
Category:	Surface-to-Air
Prime Contractor:	Douglas
Length:	41 feet
Weight:	10,710 pounds
Diameter:	31.5 inches
Wingspan:	6 feet, 2 inches
Propulsion:	Solid
Speed:	Mach 3.65
Guidance:	Command
Range:	75+ miles
Altitude:	Up to 150,000 feet
Warhead:	High explosive or nuclear

Nike Hercules and crew (Redstone)

In the early 1950s, during testing for the Nike Ajax missile system, the Army became concerned that this first generation guided anti-aircraft missile was incapable of stopping a massed Soviet air attack. To enhance the missile's capabilities, the Army explored the feasibility of equipping Nike Ajax with a nuclear warhead. When that proved impractical, however, in July 1953 the service authorized the development of a second-generation surface-to-air missile, the Nike Hercules. The Army wanted a larger missile with the capacity to carry a nuclear warhead. This would enable a single missile to destroy an entire formation of enemy bombers. The Army also wanted to extend the range of such a system which, with the Nike Ajax, was limited to 25 miles.

It was intended that the new system be designed so that the batteries would be capable of launching both the older and the newer versions of the Nike missile. Because of the increased capability of the new system, however, some changes and additions were made to the ground equipment. For example, a High-Powered Acquisition Radar (HIPAR) was installed to track targets at greater range. Alternate

Nike Hercules, ca. 1970 (Redstone)

Battery Radars (ABARs) were also installed as backup units. In addition, a Target Ranging Radar was added to counter enemy radar jamming attempts. Another significant improvement was the replacement of the liquid fuel propellant found in the Ajax missile, with solid propellant. Eliminating liquid fuels improved maintenance, safety and readiness of the missiles. The Air Force, engaged in a long-running battle for control of the nation's air defense force, opposed the development of the Nike Hercules, claiming that the Army missile duplicated the capabilities of the Air Force's soon-to-be-deployed Bomarc. Both of the competing missiles systems were eventually deployed, although the Nike Hercules would be fielded in far greater numbers.

The first Nike Hercules missiles entered service on 30 June 1958, at batteries located near New York. Philadelphia, and Chicago. Converted sites received new radars and underwent modifications so the new missiles could be serviced and stored. Because of the larger size of the Nike Hercules, an underground magazine's capacity was reduced to eight missiles. Thus, storage racks, launcher rails, and elevators underwent modification to accept the larger missiles. New sites, located away from populated areas did not have to be confined in acreage. Consequently, these batteries were all above ground with missile storage and maintenance facilities located behind earthen berms. The final stages of the Nike Hercules conversion program were completed in 1965 with 48 Army National Guard batteries participating in the program. These National Guard batteries represented 16 different states and defended 18 different areas. The missiles remained deployed around strategically important areas within the continental United States until 1974. Sites in Alaska were deactivated in 1978, and Florida sites were deactivated the following year. Although the missile left the US inventory, other nations continued to deploy the missiles into the early 1990s, and sent their soldiers to the United States to conduct live-fire exercises at Fort Bliss, Texas.

PERSHING

Associated Launch Complex

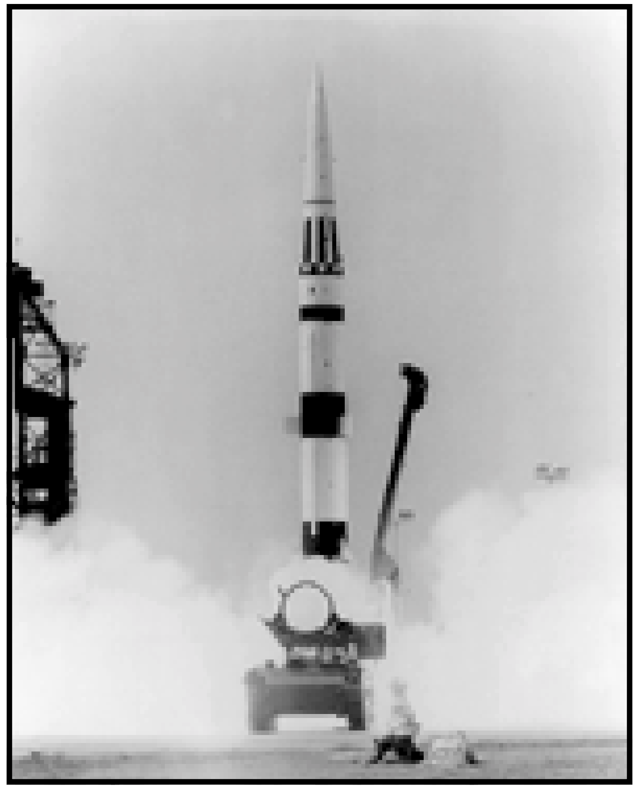
Launch Complex 30

Program Milestones (Pershing II)

Development:	1975
Production:	1981
First Successful Launch:	1977
Initial Operational Capability:	1983
Deactivation:	1991

Specifications (Pershing II)

Service:	Army
Category:	Surface-to-Surface
Prime Contractor:	Martin Company
Length:	34 feet, 10 inches
Weight:	10,000 pounds
Diameter:	3 feet, 4 inches
Wingspan:	6 feet, 9 inches
Propulsion:	Solid
Speed:	Mach 8
Guidance:	Inertial/mapping
Range:	1,000 miles
Altitude:	150 miles
Warhead:	Nuclear



Pershing I launch (KSC)

The Pershing I missile, named in honor of General John J. (Black Jack) Pershing, famed commander of the American Expeditionary Forces during World War I, was designed to replace the Army's Redstone missile. The missile was extremely mobile, being carried on four tracked vehicles suitable for cross-country travel in the absence of a road network. The first vehicle carried the missile itself and an erector launcher, the second housed a programming test and power station. A third vehicle served as a radio communications terminal center, while the fourth contained the missile's nuclear warhead and azimuth laying equipment.

On 31 October 1956, the Chief of Research and Development, Department of the Army requested that the Ordnance Corps conduct a feasibility study of a ballistic missile with a required range of 500 nautical miles and a minimum range of 750 miles. Ordnance Corps forwarded this request to the Army Ballistic Missile Agency. On 28 March 1958, the Martin Company was awarded the contract. The Army's test program for what would be known as the Pershing I missile began in 1960 and ended in April 1961.

The Pershing I employed two solid-fueled stages. A Thiokol first stage engine produced 26,290 pounds of thrust and burned for about 39 seconds. The reentry vehicle could carry a 400 kiloton nuclear warhead, effectively delivering the equivalent of 400,000 pounds of TNT. Although this was considered by critics to be an unusually large payload, the capability was established to assure that as much damage as possible would be inflicted should the missile fall short of its intended target.

The first Pershing I missile battalion, the 2nd Missile Battalion, 44th Artillery, was activated in June 1962 and the first missile was deployed in August 1963. In 1964 the first Pershing missiles replaced the Redstone in the United States and Germany. The first Pershing I battalion to be deployed overseas, the 4th Missile Battalion, 41st Artillery, became operational that same year.

On 24 May 1965, the Secretary of Defense approved a program to develop an enhanced version of the Pershing missile. Martin Marietta received the production contract for the Pershing 1-A in August 1967. This missile provided increased reliability and flexibility, additional ease of maintenance, lower cost and enhanced operational time. The primary improvement was the inclusion of the missile and its warhead in the same vehicle. In addition, the Pershing I-A and its support vehicles could be transported aboard US Air Force C-130 aircraft, which improved the speed and efficiency of deployment. The Pershing 1-A began to replace the Pershing I in 1969.

The Pershing II, an evolutionary improvement over the Pershing 1-A, was first deployed in December 1983. Through the use of a terminally guided reentry vehicle with a new warhead, new propulsion sections, and modified Pershing lA ground support equipment, the Pershing II provided increased effectiveness, longer ranges and reduced collateral damage. The Pershing II was the most advanced ground-to-ground missile ever developed by the US Army. The two-stage missile was so accurate it was capable of flying 1,000 miles and hitting a single hardened target. The maneuvering warhead guided itself to the target by making radar images of the terrain below and comparing them with stored terrain maps of the target area. Since the Pershing II was more accurate than the Pershing I and Pershing IA, it was considered capable of causing at least as much damage to a specific target while carrying a smaller weapons payload. For this reason, the nuclear warhead capability of the Pershing II was reduced to 50 kilotons compared to 400 kilotons for the Pershing I and Pershing I-A. In addition, the Pershing II was equipped with an advanced, deadly ground-penetrating warhead that could cause considerable damage even to reinforced or underground structures.

The first Pershing II test launch occurred on 22 July 1982 from Cape Canaveral Launch Complex 16. In April 1983 the central facility for transition training from Pershing IA to Pershing II was activated at Cape Canaveral Air Force Station. In May 1987, the first Pershing II night launches occurred at Cape Canaveral Air Force Station. One of the missiles launched during this testing marked the 500th flight of the overall Pershing program, which included the Pershing I, Pershing lA, and Pershing II. A total of 108 Pershing II missiles were subsequently deployed in West Germany from May 1983 through December 1985.

In 1987, United States President Ronald Reagan and Soviet Premier Mikhail Gorbachev signed the Intermediate Nuclear Forces (INF) Treaty. The

Pershing II on display at the Air Force Space and and Missile Museum (AFSMM)

treaty banned all land-based intermediate-range missiles, including the Pershing II. The increased range and pinpoint accuracy of the Pershing II were major factors influencing the Soviet Union's decision to seek a treaty in which the United States and the USSR agreed to eliminate an entire class of nuclear missiles. In accordance with treaty provisions all of the US Army's Pershing 1-A missiles had to be eliminated within eighteen months of the treaty's effective date and all of the USAF's Ground Launched Cruise Missiles (GLCMs) and the US Army's tactical Pershing II missile stages, launchers, trainers, and deployed reentry vehicles had to be eliminated by 31 May 1991. A total of 169 Pershing 1-A missiles were covered by the treaty. Army contractors completed the destruction of the last Pershing 1A missiles on 6 July 1989, five months ahead of schedule. A total of 234 Pershing II missiles were covered by the treaty. The last Pershing II was eliminated in May 1991.

The Pershing at the Cape

In December of 1958 construction started on Launch Complex 30, Pads A and B, to accommodate the Pershing research and development program. Construction was completed on 22 January 1960. The first launch of a Pershing missile from Complex 30 took place on 25 February 1960. This was followed by a second launch on 20 April 1960. The research and development phase of the Pershing, including 56 firings from the Cape, lasted until 24 April 1963.

POLARIS

Associated Launch Complex

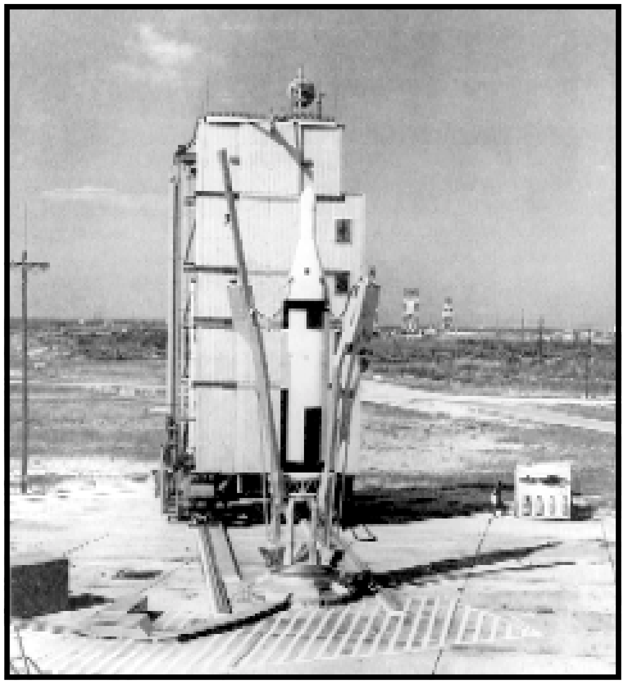
Launch Complex 25, 29

Program Milestones

Development:	1958
Production:	1961
First Successful Launch:	1960
Initial Operational Capability:	1962

Specifications (Polaris A-1)

Historical Designation:	A-1
Service:	Navy
Category:	FBM
Prime Contractor:	Lockheed
Length:	28 feet
Weight:	28,000 pounds
Diameter:	4 feet, 6 inches
Wingspan:	N/A
Propulsion:	Solid
Speed:	Mach 10
Guidance:	Inertial / Celestial
Range:	1,380 miles
Warhead:	Nuclear



Navy Polaris ready for testing at the Cape (KSC)

The Polaris missile is a submarine-launched 2-stage solid propellant missile. The missile is launched from a submerged submarine by an air ejection system. When it reaches the surface the rocket motor ignites to send the missile on its way to the target. The missile then follows a ballistic trajectory to its target. Research on this unique missile began in 1957 and it became operational in 1960. There have been three versions of the Polaris, all of which have been tested at Cape Canaveral: The Polaris A-1, A-2, and A-3.

The Polaris A-1 weighed 28,800 lbs, with a length of 28.5 ft. and a diameter of 54 in. It had a range of approximately 1,000 nautical miles. The launch of a Lockheed-built Polaris A-1 Fleet Ballistic Missile from the USS George Washington was the first launch in history to be undertaken from a submerged submarine. It occurred on 20 July 1960, off Cape Canaveral, Florida, and within three hours a second Polaris test missile was launched. On 15 November 1960, the submarine and its 16 Polaris A-1s began the first patrol.

On 2 June 1964, the USS George Washington returned to Charleston, South Carolina. This ended the initial deployment of the first Fleet Ballistic Missile (FBM) submarine, with Polaris A-1s aboard. The Polaris A-1 was retired from active duty on 14 October 1965.

The Polaris A-2 had a 1,500 nautical mile range, weighed 32,500 lbs and was 31 feet long. It was the same diameter as the Polaris A-1, four-and-a-half feet, and could be launched from the same tubes inside a submarine. The first A-2 was launched from Cape Canaveral Florida on 10 November 1960 and travelled more than 1,400 miles. The first successful submerged launch of the Polaris A-2 came from the USS Ethan Allen on 23 October 1961 off the Florida coast. The A-2 became operational on 26 June 1962, with its initial deployment on the same submarine, the USS Ethan Allen. The USS Ethan Allen was the first submarine designed, from the keel up, to be a nuclear-powered, ballistic missile submarine.

The Polaris A-3 missile was the first FBM to have a range of 2,500 nautical miles. The A-3 was 31 feet long and four-and-a-half feet in diameter. It weighed 35,700 pounds, significantly more than the A-2. The A-3 was intended to have a range of 2,500 nautical miles, 1,000 nm longer than that of the A-2. The design of the Polaris A-3, however, was restricted by the size of the submarine launch tubes. As a result, while the A-2 was a continuation and improvement of the A-1 design, the A-3 was basically a new missile.

The 2,500 nm range of the Polaris A-3 extended FBM submarine operations to the Pacific Ocean, providing greater sea room and operating area to offset the expanding Soviet anti-submarine capabilities. Another consideration for the Polaris A-3 was the need for improved accuracy and

Polaris A-1 on display at the Cape (AFSMM)

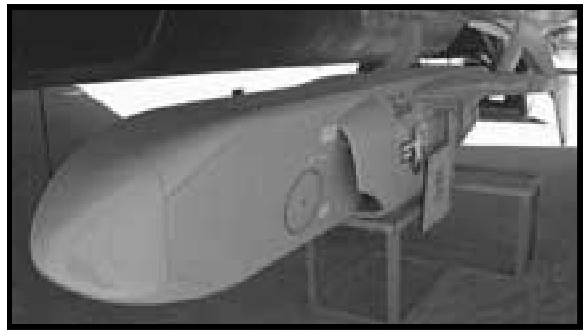
increased penetration capability against the Soviet's emerging anti-ballistic missile defense. One of the many innovations included the capability of multiple reentry vehicles.

The Polaris A-3 missile became operational on 28 September 1964 when the USS Daniel Webster began her initial operational patrol with 16 A-3 missiles. Another milestone was reached on 25 December 1964 when the USS Daniel Boone departed Apra Harbor, Guam and began the first Pacific Ocean operational patrol. With all the Eurasian land mass covered by the 2,500-mile range of the Polaris A-3 missile, the FBM System became, for the first time, a true global deterrent.

The Polaris at the Cape

Initial land-based testing for the Polaris A-1 missile took place at Pads 25A, 25B and 29A. Siting and construction of these pads began in 1956. The next year a contract was let for the construction of a 'ship's motion simulator' on Launch Complex 25B to provide for more accurate testing under the anticipated operating conditions of the Polaris missile. The first successful launch of a Polaris missile took place from Complex 25A on 18 April 1958. Several hundred Polaris launches were fired between 1958 and 1979.

QUAIL



Quail missile (USAFM)

Program Milestones

Development:	1956
First Successful Launch:	1958

Specifications

Historical Designation:	GAM-72, ADM-20
Service:	Air Force
Category:	Decoy missile
Prime Contractor:	McDonnell
Length:	12.9 feet
Weight:	1,198 pounds
Diameter:	3.3 feet
Wingspan:	5.4 feet
Propulsion:	Turbojet
Speed:	650 mph
Guidance:	N/A
Range:	250+ miles
Warhead:	N/A

The Quail was a decoy missile launched from a B-52 bomber. Its purpose was to confuse or dilute a hostile radar-controlled defense system. The US Air Force first discussed the development of such a device in October 1952, but the formal program did not begin until several years later. In February 1956 the USAF selected McDonnell Aircraft as the contractor. Flight tests began in July 1957, with the first glide test in November 1957 and the first successful powered flight, which lasted 14 minutes and covered 103 miles, in August 1958. The success of these tests resulted in a production contract in December 1958.

The Quail simulated a bomber in a number of ways. First, its operational performance was comparable to the B-52; and it could be programmed (on the ground) to make at least two changes in direction and one in speed during its 46- to 55-minute flight. Second, its slab sides and twin vertical ventral and twin vertical dorsal fins produced a radar profile similar to the bomber. In addition, the GAM-72 carried a 100-pound Electronic Counter Measures (ECM) payload consisting initially of a responder, and later of both chaff and a heat source.

Quail missiles were carried in the aircraft with wings folded. In this position each missile was 29 inches wide and 26 inches high. With wings extended the missile was 5 feet 5 inches wide, 12 feet 11 inches long and 3 feet 4 inches high. Each missile weighed 1,198 pounds. A maximum of eight missiles could be carried on the B-52 bomber and four on the B-47, although the normal loading was four and two, respectively. Before launch, the missiles were housed aboard the aircraft in two carriage racks in the bomb bay. During launch, the carriages were lowered, the missile wings extended, and the engine started automatically.

The Strategic Air Command received its first Quail missile in September 1960. By February 1961, one Quail-equipped B-52 squadron was operational. By 1963, SAC had 492 Quails in its inventory. In all, McDonnell produced 616 of the missiles. Although the Quail was operational, improvements in enemy radar gradually rendered the Quail less effective. In 1971, the commander of SAC wrote the Air Force Chief of Staff that the Quail was only slightly better than nothing. In a 1972 test, radar controllers correctly distinguished B-52 bombers from the Quail decoys 21 out of 23 times. At this point, it became clear that the Quail was no longer a credible decoy.

RASCAL

Program Milestones

Development:	1946
Termination:	1958

Specifications

Historical Designation:	GAM-63
Service:	Air Force
Category:	Air-to-Ground
Prime Contractor:	Bell Aerospace
Length:	32 feet
Weight:	13,000 pounds
Diameter:	4 feet
Wingspan:	16 feet, 9 inches
Propulsion:	Liquid
Speed:	Mach 2.5
Guidance:	Radio Command
Range:	100 miles
Warhead:	Nuclear

The Rascal missile, 1951 (Cleary)

The "Rascal," originally designated as the XB-63, was an air-to-surface supersonic guided missile armed with a nuclear warhead. Its development was inaugurated in April 1946. The Rascal was intended as a "stand off" weapon, to be launched from Strategic Air Command (SAC) B-47 stratojet bombers from distances as great as 100 miles. This would reduce the manned bomber crew's exposure to enemy defenses in the immediate target area. After being launched from its carrier aircraft, the missile would continue toward its predetermined target controlled by a self-contained inertial guidance system. The terminal dive began about 20 miles from the target. During this final phase of flight, the Rascal's course could be altered by signals from the launching "director" aircraft. The Rascal was designed for all-weather use in medium and heavy bomber operations against strategic targets.

The Rascal was first flight-tested at the Air Force Missile Development Center in New Mexico. A smaller version of the missile, called the Shrike, was tested in 1951 and 1952 to evaluate the aerodynamics and launching characteristics of the Rascal system. The first launch of a guided Rascal took place in October 1953 from a DB-47 director aircraft. Although accurate and effective, the Rascal was overtaken by rapid developments in the field of air-launched missiles, particularly the development of the more promising and longer-ranged Hound Dog missile. In late 1958, the GAM-63 program was terminated, shortly before the first Rascal-equipped SAC unit was to become operational.

REDSTONE

Associated Launch Complex

Launch Complexes 4-6, 26A

Program Milestones

Development:	1951
Production:	1952
First Successful Launch:	1953
Initial Operational Capability:	1958

Specifications

Historical Designation:	M-8
Service:	Army
Category:	Surface-to-Surface
Prime Contractor:	Chrysler
Length:	63 feet
Weight:	40,000 pounds
Diameter:	5 feet, 10 inches
Wingspan:	12 feet
Propulsion:	Liquid
Speed:	Mach 5.5
Guidance:	Inertial
Range:	200 miles
Altitude:	50+ miles
Warhead:	Nuclear

Redstone missile ready for launch (Brookings)

The Redstone missile, developed by the Army's Redstone Arsenal and a direct lineal descendant of the V-2 and forerunner of the Jupiter missile, was a highly accurate, liquid-propelled, surface-to-surface missile capable of transporting nuclear or conventional warheads against targets at ranges up to approximately 200 miles.

In June 1950, Army Ordnance transported its team of 130 German rocket scientists and engineers from Fort Bliss at El Paso, Texas, to the Army's Redstone Arsenal at Huntsville, Alabama. Under the direction of Wernher von Braun, this team began design and feasibility studies on a liquid-fueled, modified V-2 missile with a 500-mile range. The specifications of this original missile, known as the Hermes C1, were subsequently modified, reducing the desired range to 200-miles

Inspection of a Redstone missile (NASA)

to allow for a larger payload and a greater degree of mobility for field deployment.

In 1951 the program was given an accelerated status with the objective of having twelve missiles ready for flight testing by May of 1953. In the interest of rapid development, the team was directed to take advantage of existing technology and, as a result, it was decided that the new missile would use a modified North American Navaho booster.

The development program began in earnest in 1952 and, in August 1953, a Redstone made a partially successful maiden flight of 8,000 yards from the missile range at Cape Canaveral. The original Redstone missile testing program constituted 37 missiles, but of these, only 12 were used directly for Redstone ballistic missile testing. The remaining 25 missiles were designated Jupiter As and used as test vehicles in the Jupiter program (with three of these missiles being later modified and redesignated as Jupiter Cs).

Despite these diversions, the ballistic missile program progressed. Crew training began in 1956 and on 16 May 1958, Cape Canaveral hosted the first successful troop launching of a Redstone tactical missile. One month later, on 18 June 1958, the 40th Field Artillery Missile Group boarded ship for deployment in France. The development of the faster and more mobile Pershing missile system, however, resulted in the phaseout of the Redstone as an Army tactical missile system. On 30 October 1964, the Redstone tactical missile system was ceremonially retired.

Although retired from the battlefield, the Redstone continued to play a key role as a booster for the space program. A modified Redstone, redesignated the Jupiter C, carried Explorer I, the United States' first artificial satellite, into orbit.

The Redstone at the Cape

The first ballistic missile launched from the Cape was a Redstone. This launch took place from Launch Complex 4 on 20 August 1953. Through 1958, 37 Redstone missiles were tested at the Cape (including several modified Redstones used in the Jupiter program).

SKYBOLT

Program Milestones

Development:	1960
Terminated:	1963

Specifications

Historical Designation:	AGM-48A
Service:	Air Force
Category:	Air-launched ballistic missile
Prime Contractor:	Douglas
Length:	38 feet, 6 inches
Weight:	11,000 pounds
Diameter:	3 feet
Wingspan:	6 feet
Propulsion:	Solid
Speed:	Hypersonic
Guidance:	Inertial
Range:	1,000 miles
Altitude:	Inertial, celestial
Warhead:	Nuclear

Mock-up Skybolt missiles mounted on the wings of a B-52H bomber (Brookings)

The Skybolt grew out of a study program aimed at developing a long-range, air-launched ballistic missile system. Built by Douglas Aircraft, and intended for use on the B-52 bomber aircraft, the Skybolt missile was initially designed to be a complement and then a replacement for the Hound Dog. Initial planning was done in the 1950s. The decision to proceed with the Skybolt program was made in February 1960, with initial deployment projected for 1964. In June of 1960, the British government ordered 100 Skybolts that were to be carried by the Avro Vulcan. As originally envisioned, the Skybolt missile had a range of 1,150 miles, was 33 feet long, 3 feet in diameter and weighed 11,000 lbs.

As the design and development of the system proceeded, however, it became more and more evident that the disadvantages outweighed the advantages. While Skybolt was under development, other more advanced missile systems were successfully developed and deployed and this raised questions about the utility of the Skybolt missile. In December of 1962, President Kennedy canceled the Skybolt missile for political and economical reasons. The Skybolt missile was never deployed.

SNARK

Associated Launch Complex

Launch Complexes 1, 2

Program Milestones

Development:	1946
Production:	1956
First Successful Launch:	1951
Initial Operational Capability:	1957
Deactivation:	1961

Specifications

Historical Designation:	SM-62
Service:	Air Force
Category:	Surface-to-Surface (intercontinental)
Prime Contractor:	Northrop
Length:	67.2 feet
Weight:	49,000 pounds
Diameter:	4 feet, 6 inches
Wingspan:	42.2 feet
Propulsion:	Solid, turbojet
Speed:	524 mph
Guidance:	Inertial, stellar
Range:	5,500 miles
Altitude:	10 miles
Warhead:	Nuclear

The Snark missile (Brookings)

The Snark was one of the most unusual guided missiles employed by Strategic Air Command (SAC). Unofficially designated a surface-to-surface Intercontinental Missile (ICM), the winged Snark, flying at subsonic speeds, was essentially a small, turbojet-powered, unmanned aircraft. It became operational during the period of transition from an air force composed entirely of manned aircraft to a mixed force consisting of manned aircraft and missiles.

Like so many other missile programs, the genesis of the Snark program can be traced to the post-World War II period. In 1946 the Army Air Forces awarded the Northrop Aircraft Corporation a one-year research and study contract for both a subsonic and supersonic medium to long-range (1,500 to 5,000 nautical miles) surface-to-surface guided missile capable of carrying a 7,000 lb warhead. Jack Northrop, the president of Northrop Aircraft Corporation, selected the names for these missiles based on characters created by the writer Lewis Carroll: Snark for the subsonic version of the missile, and Boojum for the supersonic version. Throughout the 1940s and 1950s these programs progressed rather slowly.

This situation changed dramatically in 1955 when President Dwight D. Eisenhower assigned the highest national priority to the intercontinental ballistic missile (ICBM) development program. Even though the Snark was not an ICBM, the Air Force ordered the acceleration of its development program along with that of the Atlas missile.

Snark pre-launch check at the Cape (Cleary)

The Snark was designed to be fired from a short mobile launcher by means of two solid-fueled rocket boosters. Once airborne, the Snark was powered by a single Pratt and Whitney J-57 turbojet I engine capable of cruising at Mach 0.9 at an altitude of approximately 150,000 feet. After a programmed flight of 1,500 to 5,500 nautical miles, the Snark's airframe separated from its nose cone, and the missile's nuclear warhead followed a ballistic trajectory to its target. Plans developed by the Strategic Air Command envisioned using the Snark against enemy defensive systems, especially radars, to ensure the effective penetration of enemy air space by manned bombers.

One great advantage of the Snark was its low cost: considerably less than its competitor, the North American-built Navaho missile, and about 1/20th the cost of a Boeing-built bomber. However, there were considerable problems with the Snark missile and these problems were amply demonstrated by the missile's poor test performance. The Snark program was plagued by guidance problems. To meet the challenge of guidance over intercontinental distances, Northrop proposed an inertial navigation system monitored by stellar navigation. The first prototype of this new guidance system weighed nearly a ton. Launch failures and crashes were so common that the waters around the launch sites at Cape Canaveral became known as "Snark-infested waters". In December 1956 a Snark failed to respond to guidance commands and soared off out of control to disappear into the jungles of Brazil. A farmer discovered the missile in 1982. The testing during the 1950s revealed that on flights of 2,100 miles, on average, Snark had a degree of accuracy of plus or minus 20 miles. The Snark did not successfully complete a guidance trial until February 1960. Another problem was the missile's slow flying speed, rendering it susceptible to enemy countermeasures. Finally, the launch sites proposed for the Snark were fixed, unhardened and dangerously vulnerable to enemy strikes. As a result of these and other problems, recommendations were made to cancel the program. The Air Force and the Department of Defense, however, decided to continue a limited program for the operational deployment of one Snark squadron to provide an interim missile capability until other, more effective missile systems became available.

Despite these problems, the Snark cruise missile pioneered a number of firsts. On 26 October 1955 the Snark was the first missile to be equipped with a ballistic nose that separated from the main missile and fell in a supersonic path to its target. This method of payload delivery represented a marked improvement over the Matador's slow descent to its target. On 26 November 1955 the Snark was the first missile to use a stellar navigation system.

In December 1956 SAC published an operational plan for the Snark outlining the mission and requirements for equipping, manning, siting, activating and operating Snark units. On 21

Snark Arriving at Patrick Air Force Base, June 1952 (Cleary)

March 1957 the Air Force designated Presque Isle Air Force Base in Maine as the site for the first Snark missile base. Two months later Patrick Air Force Base was chosen as the training and operational testing site for the Snark ICM.

Snark Testing at the Cape

Initial testing for the Snark took place at Holloman Air Force Base, New Mexico. Northrop planned to transfer the Snark test program to the Air Force Missile Test Center (AFMTC) at the Cape by the end of 1951, but the Cape lacked adequate missile assembly and hangar space. Additional facilities were built before the program finally moved to AFMTC in the spring of 1952.

Initial tests at the Cape in 1952 and the first half of 1953 proved successful. Based on these results, SAC planned to activate a 105-man cadre for its 1st Pilotless Bomber Squadron (Strategic) in January of 1955. After these initial successes, however, the program suffered an almost uninterrupted series of setbacks and launch failures. The first SAC launch of a Snark missile did not take place until 27 June 1958, when SAC's 556th Strategic Missile Squadron conducted a launch under the supervision of the AFMTC's 6555th Guided Missile Squadron.

A total of 97 Snarks were launched from Complexes 1 and 2 from 29 August 1952 to 5 December 1960. Many Snarks were equipped with special landing gear to allow them to return and land on the newly constructed skid strip upon the completion of their mission.

Testing and training activities at the Cape were reduced dramatically, however, when the Air Force decided to limit Snark deployment to just one operational squadron. In January 1959 SAC activated the 702nd Strategic Missile Wing (ICM-SNARK) at Presque Isle AFB, Maine. The 556th Strategic Missile Squadron was assigned to the 702nd in April of that same year and left for Maine on 7 July 1959. The 702nd placed the first Snark ICM on alert on 18 March 1960 and by the end of fiscal year 1960 a total of four Snark missiles were on alert. Little more than a year later President John F. Kennedy, in a special defense budget message, directed the phase out of the missile, calling the Snark obsolete and of marginal military value relative to rapidly expanding ballistic missile programs. The last Snark was launched at the Cape on 5 December 1960 and on 25 June 1961 SAC inactivated the 702nd Strategic Missile Squadron.

SUBROC

Program Milestones

Development:	1958
Production:	1964
Initial Operational Capability:	1965

Specifications

Service:	Navy
Category:	Anti-submarine
Prime Contractor:	Goodyear
Length:	20 feet, 7 inches
Weight:	4,000 pounds
Diameter:	1 foot, 9 inches
Wingspan:	N/A
Propulsion:	Solid
Speed:	Supersonic
Guidance:	Inertial
Warhead:	Nuclear

Subroc missile being loaded aboard a submarine (FAS)

In 1959, the Naval Ordnance Laboratory at White Oak Maryland began developing the SUBROC (SUBmarine ROCket) anti-submarine missile. The Subroc missile system was designed to detect enemy submarines at long range, compute the target's course and speed, and then fire the large Subroc missile. The missile was designed to be ejected from a standard torpedo tube. Once clear of the ship, the solid fuel rocket motor ignited and propelled the missile towards the surface. After breaking the surface the booster accelerated to a predetermined altitude and speed before separating from the payload and tumbling back into the sea. The missile would then continue flying up to 25-30 miles to the computed sea impact point. After impact with the sea, the missile would continue traveling underwater, performing several underwater terminal maneuvers to close with the predicted position of the intended target. After finding its target the Subroc's warhead, a 39-inch long Mark 55 thermonuclear warhead, weighing approximately 460 pounds, would be detonated.

TARTAR

Specifications

Service:	Navy
Category:	Surface-to-Air
Prime Contractor:	Convair
Length:	15 feet
Weight:	1,500 pounds
Diameter:	1 foot, 1 inch
Wingspan:	3 feet, 6 inches
Propulsion:	Solid
Speed:	Supersonic
Guidance:	Radar
Range:	10 miles
Warhead:	High Explosive

Tartar launch, 1966 (WSMR)

The Tartar missile system was a compact weapon system designed to serve as the primary anti-aircraft battery aboard destroyers armed with guided missiles, and as a secondary battery aboard some cruisers. The Tartar was essentially a smaller version of the Navy's Terrier missile, but with a different guidance system, a smaller frame and a longer range. This small missile, the smallest of the Navy's guided missiles in the surface-to-air category, was highly effective against both low-altitude and high-altitude targets. The Tartar was first test-fired off the California coast in 1960 by the USS Norton Sound. The Tartar missile system was later replaced by the Standard Medium Range Missile (SMRM) system.

THOR

Associated Launch Complex

Launch Complex 17, 18

Program Milestones

Development:	1955
Production:	1957
First Successful Launch:	1957
Initial Operational Capability:	1958
Deactivation:	1963

Specifications (Thor IRBM)

Historical Designation:	SM-75, PGM-17A
Service:	Air Force
Category:	IRBM
Prime Contractor:	Douglas
Length:	65 feet
Weight:	110,000 pounds
Diameter:	8 feet
Wingspan:	N/A
Propulsion:	Liquid
Speed:	Supersonic
Guidance:	All-inertial
Range:	1,500 miles
Warhead:	Nuclear

Thor ready for launch (Cleary)

On 1 December 1955, President Eisenhower assigned the highest national priority to the development of the Thor and Jupiter intermediate range ballistic missiles (IRBMs), placing them on equal footing with the ICBM development program. The IRBM research was conducted concurrently with that for the ICBM, but the IRBM's less restrictive performance requirements meant the missile could be developed and rendered operational more quickly than the larger, more complex ICBM. Intelligence reports indicated that the Soviet Union had made significant advances in their IRBM research, a situation that posed a serious threat to the security of the United States' allies in Western Europe. The IRBM, therefore, was intended in some respects as an emergency 'stop-gap' measure, based in Europe, until the ICBMs could be developed and deployed.

On 22 March 1956 Headquarters USAF assigned responsibility for Thor's initial operational capability (IOC) jointly to the Air Research and Development Command and the Strategic Air Command (SAC). Thor IOC would consist of one wing of 120 missiles, situated at three SAC bases in the United Kingdom. Each base would have four "soft"and dispersed launch complexes containing five launchers. Planning called for the first 10 Thor IRBMs to attain combat status by October 1958, with the entire 120 missile force ready by 1 July 1959. SAC was responsible for the overseas deployment of the operational units.

Like every missile program before it, the Thor development program underwent a series of changes. On 28 March 1957, Eisenhower approved a revised Thor IOC, calling for 60 missiles (4 squadrons of 15 missiles each) first scheduled to become operational by July 1959, with the entire force ready by July 1960. After the striking success of the Soviet Union's Sputnik I launch, this plan was revised yet again. On 30 January 1958 a new plan called for four 60-missile Thor squadrons, the first to be operational by 31 December 1958.

On 25 March 1957, President Dwight D. Eisenhower and British Prime Minister Harold Macmillan issued a joint communiqué announcing a broad agreement on the deployment of Thor IRBMs in the UK. Eleven months later the two governments signed an agreement providing for the deployment of four Thor IRBM squadrons to England. The 705th Strategic Missile Wing (SMW) was activated on 20 February 1958 at Lakenheath Royal Air Force Station, UK to monitor the Thor IRBM program in the UK and to provide technical assistance to the four RAF Thor squadrons. Shortly thereafter the Air Force transferred the 705th SMW to South Ruslip and

RAF Thors at the ready (FAS)

merged it with Headquarters, 7th Air Division.

Transferred to the Royal Air Force on 22 June 1959, the 77th RAF SMS at Feltwell England became the first England-based Thor IRBM squadron to reach operational status. On 11 September and 22 December 1959 the second and third England-based Thor IRBM squadrons were declared operational and assigned to the RAF. The fourth and final was turned over to the British on 24 April 1960.

The phaseout of the British Thors was completed on 20 December 1963. McNamara told the British Minister of Defense in May 1962 that the United States would not provide logistical support for the Thors after 31 October 1964, prompting the British government to decide the phaseout of the Thors. SAC's 7th Air Division planned and carried out the phaseout of the four squadrons. On 29 November 1962 the first Thor came off alert at the 98th Royal Air Force SMS in Driffield. Nine months later, on 15 August 1963, the last fifteen Thor IRBMS were declared non-operational.

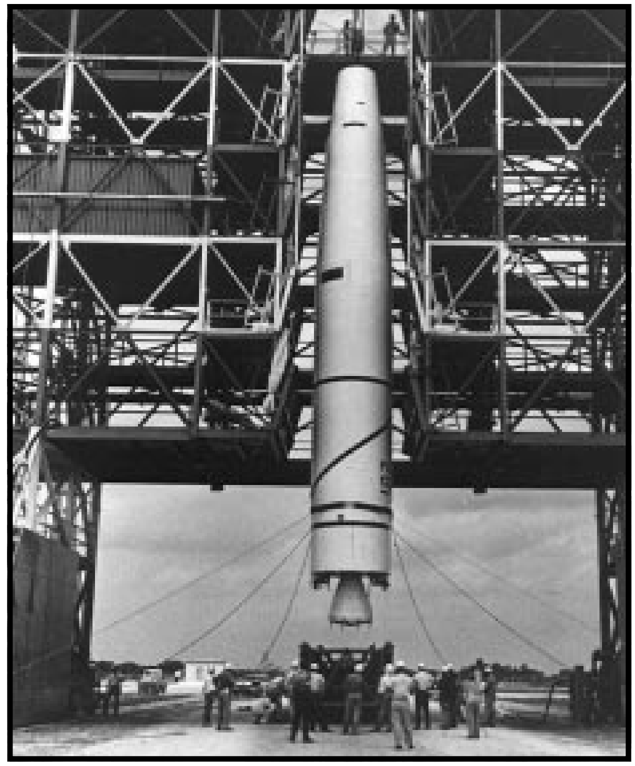
The Thor boosters continued to serve in the United States as a booster to launch payloads into space. The Thor was matched with several different high-energy upper stages in the late 1950s, including the Lockheed Agena A and Agena B upper stages, and continues to serve as the first stage of the Delta II, used for Global Positioning Satellite (GPS) and commercial space launch operations.

Nearly all of the Thor-Agena combinations were flown in support of USAF programs. One of the most important of these was the Discoverer program. This program used Thor-Agena A combinations and these launches resulted in a number of firsts: first to return capsules from space with successful sea and aerial recoveries, first to be placed in polar orbit, first to obtain a nearly circular orbit, and first to restart in space.

Thor-Able, using the second and third stage of Vanguard, was first flown by NASA on 11 October 1958. The successful Thor-Delta was first flown on 13 May 1969. Even the US Navy used a Thor Booster mated with the Able Star. As a missile or a space booster, the Thor was launched over 500 times. The last Thor launch was that of a Thor-Delta on 6 October 1981.

The Thor at the Cape

The first Thor was launched from Complex 17 on 25 January 1957. This initial launch failed but a second launch, on 19 April, was successful. Testing continued through 1959 on both the IRBM and space launch vehicle versions of the Thor. Pad 17A alone supported a total of ten Air Force-sponsored Thor-Able, Thor-Able I and Thor-Able II launches. Thor-Able boosters were used for NASA's Pioneer V deep space mission to Venus in March 1960 and its Tiros I weather satellite mission in April 1960. Pads 17B and 18B also supported Thor launches using various configurations.



Thor missile in the service tower at Pad 17B, 6 May 1957 (Cleary)

Thor boosters were also used in the Aerothermodynamic/Elastic Structural Systems Environmental Test (ASSET) program. The ASSET program was undertaken to gather data for the development of full-sized spacecraft capable of maneuvering in space and reentering Earth's atmosphere. Six ASSET vehicles were launched from the Cape using Thor boosters from 18 September 1963 and 24 February 1965.

TITAN

Associated Launch Complex

Launch Complexes 15-16, 19-20, 40-41

Program Milestones

Development:	1955
Production:	1962
First Successful Launch:	1959
Initial Operational Capability:	1962

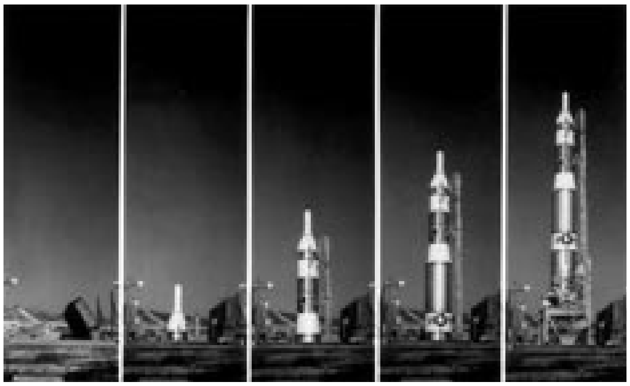
Specifications (Titan I)

Historical Designation:	SM-68A
Service:	Air Force
Category:	ICBM
Prime Contractor:	Martin
Length:	98 feet
Weight:	220,000 pounds
Diameter:	10 feet
Wingspan:	N/A
Propulsion:	Liquid
Speed:	Supersonic
Guidance:	Radio-Inertial
Range:	6,300 miles
Warhead:	Nuclear

Titan I being raised for launch (FAS)

The Titan I (SM-68) is counted alongside the Atlas as a first-generation intercontinental ballistic missile. In contrast to the Atlas, however, the Titan I, was a two-stage, liquid-fueled, rocket-powered ICBM. Produced by the Martin Company, the Titan I incorporated both radio and all-inertial guidance. Deployed in a 'hardened' silo-lift launcher, the Titan I had an effective range of 5,500 nautical miles.

In August 1960, the first operational prototype of the Titan I was tested successfully in a 5000-mileflight from Cape Canaveral. Many tests followed until the first complex of this new ICBM was accepted as operational by SAC at Lowry AFB, Colorado in April 1962. It was determined to deploy six Titan I squadrons and on 16 August 1962, the sixth and final Titan I squadron (the 569th Strategic Missile Squadron) was declared operational at Mountain Home AFB, Idaho.



Titan I elevation sequence (FAS)

Soon after the deployment of the Titan I squadrons, work began on the development of the 'second-generation' Titan II. The Titan II, also manufactured by the Martin Company, was a large two-stage, liquid-fueled, rocket-powered ICBM that incorporated significant performance improvements over the earlier model Titan I weapon system. Titan II had more powerful engines (first stage - 430,000 pounds of thrust, second stage - 100,000 pounds of thrust, compared to 300,000 pounds and 80,000 pounds for the Titan I), a larger warhead, all-inertial guidance, hyperbolic fuel, and an on-board oxidizer, and the capability of being fired from a hardened underground-silo launcher. This capability to be launched from within its silo, as opposed to the Titan I that had to be raised up to ground level prior to firing, made the missile less vulnerable and more capable of withstanding an enemy nuclear strike.

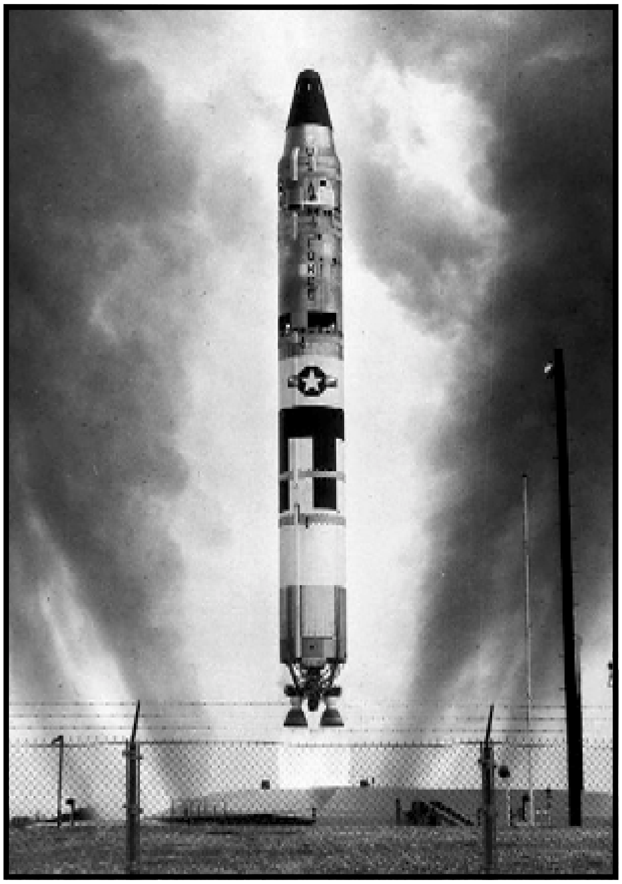
Each Titan II silo was directly connected to an underground launch control capsule manned by a missile combat crew of two officers and two airmen. The Titan II, like the Titan I, had an effective range of approximately 5,500 nautical miles. The Air Force had approved the development of the Titan II ICBM in October 1959. By 28 March 1961, the missile force included six Titan I and six Titan II squadrons. SAC activated the first Titan II squadron on 1 January 1962 and during the next eight months activated five more squadrons.

Development of the Titan II began in June 1960 when the Air Force awarded a contract to the Martin Company for the development of an advanced version of the Titan system. By July 1962, Titan II missiles had already made three flights down the Atlantic missile range.

On 8 June 1963, the 570th Strategic Missile Squadron at Davis-Monthan became the first Titan II unit to achieve operational status. Headquarters SAC completed the deployment of the second-generation ICBM weapon system on the last day of 1963 when it declared the sixth and last Titan II unit, the 374th Strategic Missile Squadron at Little Rock Air Force Base, Arkansas, operational.

As a result of the Titan II, plans were made to phase out the Titan I. The operational phaseout of the Titan I missile was completed on 1 April 1965 when the last Titan I was removed from alert at the 569th Strategic Missile Squadron, Mountain Home AFB, Idaho.

By 1981, the Titan II weapon system had served the nation for eighteen years, eight years longer than its predicted service life. The system's advanced age, combined with three accidents that destroyed two sites and killed four airmen, had cast doubts on its safety and effectiveness. SAC, anticipating a Department of Defense (DOD) initiative, began to consider replacement options in October 1980. One month later, the Senate Armed Services Committee asked the Defense Department to prepare a formal Titan II safety report. SAC's replacement options review became the basis for the DOD safety report released in February 1981. The DOD study acknowledged Titan II's significant, albeit declining usefulness



Titan II silo launch (FAS)

in preserving nuclear deterrence, and recommended deactivation of the Titan system as part of the ICBM modernization plan. During the interim, SAC would continue to improve Titan hardware and safety procedures.

On 2 October 1981, Deputy Secretary of Defense Frank C. Carlucci directed the retirement of the Titan II at the earliest possible time. The deactivation program, designated Rivet Cap, formally began with the removal from alert of site 571-6 at Davis-Monthan AFB, Arizona, on 30 September 1982. Titan II deactivation was completed on 23 June 1987 when technicians removed the last Titan II missile from its silo at Little Rock AFB, Arkansas. The era of liquid propellant ICBMs came to a close on 18 August 1987 with the inactivation of the last Titan II wing, the 308th Strategic Missile Wing at Little Rock AFB.

The Titan ICBM at the Cape

The first Titan I arrived at Cape Canaveral on 19 November 1958. That missile was erected at Complex 15 on 23 November, but it had to be sent back to Martin's factory a week later for an oxidizer line replacement. The first four Titan I test missiles were eventually launched from Complex 15 on 6 February, 25 February, 3 April and 4 May 1959. All four missiles met virtually all of their test objectives. Unfortunately, the next two launches failed dramatically. The first rose slowly off the pad before losing all thrust, falling back on the launcher ring and exploding. The second missile failed in similarly spectacular fashion. Several other failures followed in quick succession, but eventually the Titan I met all of its test objectives. After a total of 47 test flights, Titan I was declared operational in December of 1961.

The Titan II was first launched from the Cape on 16 March 1962. Following 35 test flights, the Titan II was declared operational in December of 1963.

Section III

Bibliography and Credits

CREDITS

Photographic Credits

The following abbreviations are used in the photographic credits:

AFSMM	Air Force Space and Missile Museum, Cape Canaveral Air Force Station
Brookings	Brookings Institution
Cleary	Cleary, Mark C., *The 6555th: Missile and Space Launches Through 1970* (45th Space Wing History Office, 1991). Patrick Air Force Base.
FAS	Federation of American Scientists
KSC	Kennedy Space Center Archives
NASA	NASA Image Exchange
Redstone	Redstone Arsenal
Spaceline	Cliff Letheridge's Spaceline.org website
USAFM	United States Air Force Museum, Wright-Patterson Air Force Base
WSMR	White Sands Missile Range

Other Credits

In researching information to include in the 'specifications' section for each missile system, it proved extremely difficult to find two authors (or two fact sheets, for that matter) that agreed on all the details. To achieve some level of consistency, most specifications for ICBM and IRBM systems were taken from John C. Lonnquest and David Winkler, *To Defend and Deter: The Legacy of the United States Cold War Missile Program* (United States Army Construction Engineering Research Laboratory, Special Report 97/01, Champaign, 1996). Specifications for the cruise, or winged, missiles were taken primarily from Kenneth P. Werrel, *The Evolution of the Cruise Missile* (Air University Press: Maxwell Air Force Base, AL, 1985). Many of the Army missile specifications were taken directly from the relevant monograph produced by the USAMC or the ABMA (see Bibliography). Information relating to program milestones is taken primarily from the data presented in the *U.S. Missile Data Book* (Data Search Associates: Huntington Beach, CA, 1976, 1991 and 1994).

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White Sands Missile Range *(http://www.wsmr.army.mil)*

Wright-Patterson Air Force Base, US Air Force Museum *(http://www.asc.wpafb.af.mil)*

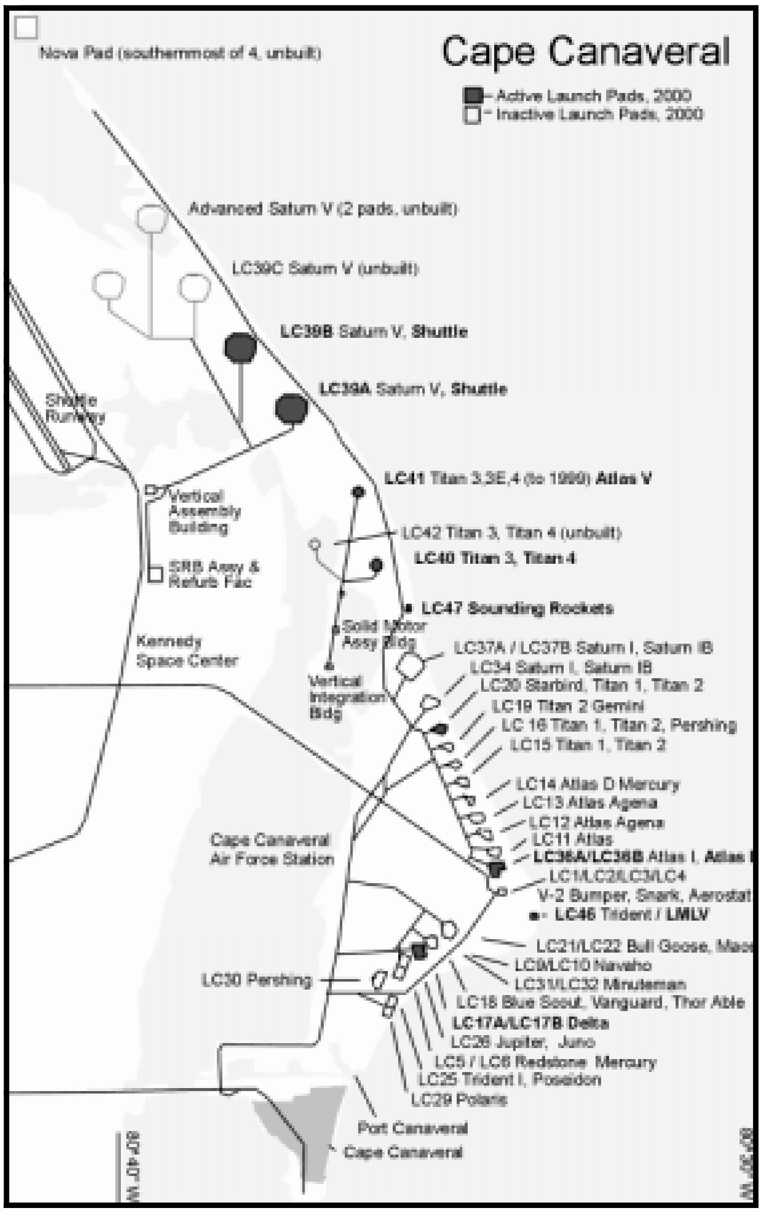
Section IV

Appendices

Appendix I:

Map of Launch Complexes and Associated Missile Systems at Cape Canaveral Air Force Station

(Graphic courtesy of: Encyclopedia Astronautica, http://www.astronautix.com/)



Appendix II:

Launch Complexes and Associated Launch Vehicles

(From: “Facts Book: Air Force Eastern Test Range” produced by the Office of Information, Headquarters, Air Force Eastern Test Range, Patrick Air Force Base, Florida, 1969; and “Facilities at John F. Kennedy Space Center, NASA and Cape Canaveral Air Station,” Kennedy Space Center, Florida, December 1997.)

LC	Original Mission	Additional Mission(s)
1	Snark	Matador
2	Snark	Matador
3	Bumper	Bomarc, Matador, Hugo, X-17, Polaris, Spin Balance Facility (Delta)
4	Bomarc	Redstone, Jason, Hugo, X-17
5	Redstone	Jupiter, Juno, Mercury-Redstone
6	Redstone	Jupiter, Mercury-Redstone
9	Navaho	Minuteman (as LC- 31)
10	Navaho	Minuteman (as LC-32)
11	Atlas	
12	Atlas	Atlas-Able, Atlas-Agena
13	Atlas	Atlas-Agena
14	Atlas, Atlas ATDA	Atlas-Able, Atlas-Agena, Atlas ATDA, Mercury-Atlas
15	Titan I	Titan II
16	Titan I	Titan II, Pershing II
17A	Thor	Thor-Able, Thor-Delta, Delta
17B	Thor	Thor-Able, Thor-Able-Star, Delta-Thor. Delta, Thor-Asset
18A	Vanguard	Blue Scout, Blue Scout Jr., Vanguard
18B	Thor	Thor-Able, Blue Scout
19	Titan I	Titan II (Gemini)
20	Titan I	Titan IIIA, Starbird
21	Bull Goose	Mace
22	Bull Goose	Matador, Mace

Appendix II (cont)

LC	Original Mission	Additional Mission(s)
25A	Polaris	Trident I
25B	Polaris	
25C	Poseidon	
25D	Poseidon	
26A	Jupiter	Redstone, Juno
26B	Jupiter	Juno II
29	Polaris	
30A	Pershing I	
30B	Pershing I	
31A	Minuteman	
31B	Minuteman	
32A	Minuteman	
32B	Minuteman	
34	Saturn I	Saturn IB
36A	Centaur	Atlas-Centaur
36B	Centaur	Atlas-Centaur
37A	Saturn I	Saturn IB
37B	Saturn I	Saturn IB
39A	Saturn V	Space Shuttle
39B	Saturn V	Space Shuttle
40	Titan IIIC	Titan IV
41	Titan IIIC	Titan IV, Titan-Centaur
46	Trident	
47	Sounding Rockets	

Appendix III:

Major Missile Launches to 20 September 1969

(from: "Facts Book: Air Force Eastern Test Range" produced by the Office of Information, Headquarters, Air Force Eastern Test Range, Patrick Air Force Base, Florida, 1969)

Missile	# of Launches	Missile	# of Launches
Bumper	2	Titan I	47
Lark	40	Titan II	35
Matador	286	Titan IIIA	4
Snark	97	Titan IIIC	13
Bomarc	70	Bold Orian 199B	12
RVA-10	4	ALBM 199C	3
Navaho X-10	15	Draco	3
Navaho XSM-64	11	Jason	12
Bull Goose	20	Hound Dog	77
Mace	44	Pershing	56
Redstone	33	Delta	64
Jupiter	65	Skybolt	6
Juno	10	Scout	16
X-17	38	Centaur	20
Atlas	143	Minuteman I	54
Thor	54	Minuteman II	20
Thor-Able	27	Minuteman III	8
Vanguard	14	Saturn I	10
Polaris	320	Saturn I-B	5
Poseidon	11	Saturn V	6

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14. ABSTRACT

Cape Canaveral Air Station (CCAS), FL has played a pivotal role in the American space program that began largely as a result of the Cold War.

Public Laws require the United States Air Force to identify and evaluate properties under Air Force jurisdiction that are potentially eligible for the National Register of Historic Places (NRHP). In 1993, CCAS's Launch Complex 26, a dual pad complex, was determined eligible for listing on the National Register of Historic Places. Launch Complex 26 is used for Cape Canaveral's Space Museum and is the home of approximately 50 military rockets and missiles on static display.

This report documents on-site and archival research on the rocket and missile static displays on Launch Complex 26. It includes a history of the military space program; the history of each missile system represented by the displays; and historic and current black and white photographs.

15. SUBJECT TERMS

Air Force Space Museum	missile systems	military history
Cape Canaveral Air Force Station, FL (CCAFS)	military weapons	weapons systems

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